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Revising the Roads Investment Strategy in Rural Areas

An Application for Uganda

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Abstract

Based on extensive data collection in Uganda, this paper demonstrates that the rural access index, as defined today, should not be a government objective because the benefit of such investment is minimal, whereas achieving rural accessibility at less than 2 kilometers would require massive investments that are not sustainable. Taking into account the fact that plot size is limited on average to less than 1 hectare, a farmer's transport requirement is usually minimal and does not necessarily involve massive investments in infrastructure. This is because most farmers cannot fully load a truck or pay for this service and, even if productivity were to increase significantly, the production threshold would not be reached by most individual farmers. Therefore, in terms of public policy, maintenance of the existing rural roads rather than opening new roads should be given priority; the district feeder road allocation maintenance formula should be revised to take into account economic potential and, finally, policy makers should devote their attention to innovative marketing models from other countries where smallholder loads are consolidated through private-based consolidators.

This paper—a product of the Transport Unit, Africa Region—is part of a larger effort in the unit to evaluate impact of rural roads on economic development. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at graballand@worldbank.org.

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An Application for Uganda

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1. Introduction

The coming together of increased awareness of the new economic geography[1] and economic growth[2] is drawing renewed attention to rural isolation, rural access, and the role of transportation in improving rural economic growth and livelihoods.

The rationale for increasing rural access to markets follows the fundamental and compelling economic logic of scale economies and the gains from trade dating back to Adam Smith: rural producers who specialize in production and trade their surpluses can prosper faster.

In low-income countries (LIC) where rural infrastructure and structural transformation is less advanced, the chain of economic logic justifying rural road building is compelling but more complicated than it might at first seem. Most rural dwellers are farmers, many of them self-sufficient in food, with some selling their surplus food and cash crops to buy the necessities they cannot produce (including food out of season), and to pay health and school fees. Their incomes therefore depend largely upon their agricultural production. In turn their agricultural productivity and income can increase if they use more modern inputs (seed, fertilizer, pesticides). This requires that they have: (i) access to markets in which to sell their produce (to raise the money for inputs and other necessities) and to buy these inputs, and (ii) affordable transport through which to attain this market access. Affordability, i.e. monetary access depends on the relative prices they receive and face, which in turn depends on supply and demand and the costs of moving crops and inputs between secondary and primary markets and farm gates; plus market information asymmetries; and the availability of market competition among buyers, sellers, and transporters. For instance crop prices can collapse at times of surplus if markets are localized and oversupplied. But this is less likely to happen if markets are well integrated within a country and with export markets and if price smoothing is possible through storage. The affordability of transport to rural agents in turn depends on its price. This depends upon the fixed and variable costs of moving a unit of inputs and/or product, the value per unit eventually bought or sold, the volumes carried (in turn affected by the number and size of market suppliers and the transactions costs of

[1] Among others, we can quote Venables and Kanbur (2005) and World Bank (2009.1).
[2] Commission on Growth and Development (2008).

dealing with them), and the degree of market dominance and competition among transporters. The costs and viability of high volume mechanized transport improve when roads are built. So does access to markets through other more traditional means of transport. Which mode of transport is eventually used will depend upon costs and prices.

Following this results chain, rural roads development can therefore enhance market access and welfare for rural communities; and these gains can increase as road conditions and market integration improves. But it does not necessarily follow that building rural roads will always and everywhere generate these feasible results. It depends upon the assumptions, prices and market conditions along the results chain. Whether these hold is an empirical question which is all too often glossed over by development practitioners in determining the appropriate levels and locations of public investments in rural roads, and indeed in appraising their viability *ex ante*.

This empirical paper investigates the assumed link between rural roads and incomes in rural Uganda. It then assesses the criteria currently used in Uganda to decide on how to prioritize public funds in the rural roads sector. It presents the results of an alternative methodology that could help maximize the economic growth gains from rural roads investments. Finally the paper offers policy recommendations to the Government of Uganda (GOU) on how to get the most out of the existing stock of rural roads, which also cover transport logistics and marketing reforms.

A brief literature survey

The empirical literature on the economic costs of isolation and the benefits of access in LIC is growing. For Madagascar, Stifel and Minten (2008) find that isolation (defined as travel time during the dry season from the commune center to the nearest urban center) implies lower agricultural productivity, increased transport and transaction costs and increased insecurity. The authors found a major jump of per capita consumption from the least remote quintile to the second quintile and therefore a negative relationship between isolation and poverty. Distance from the plot to an all-weather road and the cost of transporting rice significantly decrease the use of fertilizer in rice production.[3] Controlling for soil fertility (and thus for non random placement of roads), they demonstrate that crop yields for the three major staple items in Madagascar (rice, maize, and cassava) are lower in isolated areas relative to non-isolated areas. Sahn and Stifel (2003) also demonstrate that living standards in rural areas lag far behind those in urban areas.

There is also evidence that road improvement can exert a direct impact on poverty. In Lao People's Democratic Republic, rural poverty decreased by 9.5 percent between 1997-98 and 2002-03, of which improved road access played a significant part. The road improvement came in the form of providing all-season roads to areas that previously had only dry-season access (Warr, 2005). Similar evidence was identified in Ethiopia, where 15 villages were surveyed about their links to market towns (Dercon and Hoddinott, 2005). From the finding the authors conclude that increases in the road quality, i.e. from a dry to an all-season road, have strong positive effects on the consumption growth for rural households. Consistent with intuition, these results imply that is not just the presence of a road, but the presence of a road that is passable year-round that aids in poverty reduction. Low service to rural areas can be worsened during the rainy season in high-rainfall Africa, when roads are wiped out (Ellis and Hine, 1998).

The World Development Report (WDR) 2008 reports evidence of increasing economic inequality between leading and lagging areas within countries, as well as a threshold effect of investments in low economic density areas. Countries are not homogenous entities, but are comprised of areas that are combinations of economic development and population. The term "low economic density area" refers to areas lacking economic development, i.e. industries and services, usually coupled with high poverty rates and occasionally high population density. Additionally, developing countries also face the paradox of declining poverty rates occurring simultaneously with increasing inequality between leading and lagging regions, examples provided in the WDR 2008 include China, Ghana and India. In response to the situation in lagging areas, governments have attempted to attract industry and disperse economic development more

[3] In fact, the simple regression model they use to illustrate the correlates of transportation costs demonstrates that distance is a significant determinant of transporting 50 kg of rice to nearest major city. A multicolinearity problem then arises and may bias results.

evenly across their countries. The WDR 2008 cites poor access to markets, services and high transport costs as prohibiting the full integration of lagging and leading regions of countries. As noted in WDR 2008, connectivity within a country will assist in ending the "geographical poverty trap," which occurs when generations of people are trapped in the same lagging region/area/village without any means of escape.

Conversely, there are several instances where developing countries lost out when trying to revive lagging areas. Unfortunately, the policies did not succeed in reviving the lagging areas. Between 1970 and 1980 the Mexican government offered large reductions in import duties if firms located outside of the three major cities, this was unsuccessful in relocating firms. The Indian Industrial Policy Resolution of 1956 attempted to direct investment into lagging areas through strict licensing; applications for investment in leading areas were rejected and funneled to lagging ones. In addition, major government projects were also focused in lagging areas. In the 1970s, Thailand offered a tax holiday for companies in lagging areas; nevertheless, this policy did not entice organizations to move to these areas. In response to these unsuccessful examples, the WDR 2009 suggests allowing the market to first choose the location, and then the government to assist in speeding up the pace of development through investment in infrastructure.

Uganda has experienced positive economic growth over the past two decades, since 1988 annual GDP growth has ranged from 3 to 12 percent with an average of six percent growth over the time period (World Development Indicators). Despite this overall growth, poverty remains prevalent in rural areas of Uganda (Deininger and Okidi 2003; Fan et al. 2004, World Bank 2007 and 2009.3). Several articles address this issue in the contexts of roads and access to markets. The prevailing notion is that as household distance from roads increases (on roads which eventually lead to markets), the income/consumption expenditure of household decreases.

Utilizing district level data from 1992, 1995, and 1999, it is established that government expenditures on roads have a significant impact on poverty reduction in rural Uganda (Fan et al. 2004). Further research has shown that market availability increases household participation in export crops which leads to higher income among these households (Balat et al. 2008). By utilizing instrumental variable regressions the authors concluded that farmers with fewer markets for agricultural export crops are poorer than those with the markets. By facilitating market access, through roads, the Ugandan government can encourage participation in export leading to decreased rural poverty.

Stifel and Minten (2008) site high transportation costs as a reason for the positive relationship between poverty and isolation. The high costs may be connected either to a lack of passable roads or a lack of a mode of transportation, including public transportation. As noted previously, Balat et al. (2008) shows that market availability in Uganda increases household participation in export cropping leading these households to be less likely poor compared to non-export crop households. The study concludes that government policies which decrease trade costs, including transport service costs, will promote export trade and lead to poverty reduction.

At a more operational level, the GOU has endorsed the conclusions of a growth diagnostic prepared under the World Bank's Country Economic Memorandum (CEM) (2007) that emerging infrastructure gaps are the most likely constraints that could slow growth down. The government has substantially increased road investments in the national budgets of 2007/08 and 2008/09[4].

The rural access index (RAI) (proportion of rural people who live within two kilometers (km), typically equivalent to a 20-minute walk, of an all-season road[5]) has been set as the most important outcome indicator for the World Bank in its transport operations in most LIC. This indicator, also used in Uganda, is said to be a compromise between those who find any distance even less than one km too great a struggle (i.e., the elderly and disabled) and those who are accustom to walking great distances because of

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[4] This paper does not deal with the social benefits of roads. It is nevertheless important to note that additional social benefits are usually associated with roads and transportation services to rural areas of Africa. These additional benefits, access to health care and education, are supported by papers on Uganda by Fan et al. (2004), Schipper et al. (2007), Odoki et al. (2008) and on other countries by Ellis and Hine (1998), Jacoby (1998), Gibson and Rozelle (2003). One World Bank paper has even attempted to integrate social benefits into road appraisal, using Uganda as a case study (Odoki et al. 2008). By collecting data at the national (Ministry of Finance Planning and Economic Development and Ministry of Works and Transport), district (Mbale and Dulu), and community levels, the authors were able to identify the perceived social benefits of roads at each level. At the community level the top three social benefits, in order, were: increased access to health facilities, clean water sources and educational institutions. Only at the district and national level was access to markets listed. Thus, it is not only economic benefits, but social ones that drive the development and the desire for roads in rural areas.

[5] An all-season road is a (gravel or bitumen paved) road that is motorable all year by the prevailing means of rural transport (often a pick-up or a truck which does not have four-wheel-drive). Predictable interruptions of short duration during inclement weather (e.g. heavy rainfall) are acceptable, particularly on low volume roads. This definition has been subject to controversies in some countries.

their remoteness. However, the statistical backing of the significance of the 2 km measure seems to be absent. Moreover, definition of rural roads usually depends on the responsible agency for the road and not necessarily on the economic function of the road.

Literature on the impact of rural roads on agricultural growth and poverty has flourished. One of the most prominent was Fan el al. (2004) who estimates the effects of different government expenditures on agricultural growth and poverty in rural Uganda. The analysis was carried out at the national, regional and district levels using data collected from the national government and the aggregation of the Uganda National Household Surveys (UNHS) to the district level, from 1992, 1995, and 1999. The expansion on this paper is in response to some of the shortcomings of the article, mainly in reference to the data used and the missing components of the survey that do not allow for a thorough analysis.

Indeed, a common problem in this literature is that the distance to roads is only an estimate, which may suffer from inaccuracies or may misrepresent the situation.

Another frequent problem of the transport research is simultaneity bias/causality. When examining the relationship between income/consumption and road construction there is a possibility that they both may be influencing one another. Does road construction bring about higher incomes? Or do higher income areas demand new roads in their vicinity? A method used to overcome this problem is simultaneous equations which are used by Fan et al. (2004). However, the article was concerned with other variables and did not use road distance as both an independent and dependent variable. Therefore, there is no way to be sure that the causality flowed from the roads to the improved income and not the other way around.

Furthermore, because the survey does not delve into services or costs, Fan et al. are limited to only investigating the impact of government expenditure on road construction. They were unable to examine the supply side constraints of transport that exist in Uganda. As noted above, though a community may be in close proximity to a road, a lack of transportation services will limit the community's potential growth. This is especially the case when costs of these services are prohibitively high resulting from poor road conditions, a mismatch in supply and demand, or high vehicle costs. In the end, Fan et al. use of secondary data forced their analysis in a certain direction as they used the information provided by the surveys. The combination of all these reasons and limitations motivated the collection of primary data with which to conduct this analysis of the road and transport services situation in Uganda.

Should the quest to achieve the 100 percent of access to rural roads at less than 2 kilometers be continued?

Across the LIC and in particular Sub-Saharan Africa (SSA), governments and their development partners now face a dilemma: should they open more rural roads to achieve a complete RAI in a country or should they drop the aim of the full RAI because of sustainability problems and concentrate more resources on maintenance of the existing road network?

Road impact does vary. Over the last thirty years a large number of road impact studies have been carried out and, perhaps unsurprisingly, in view of the different circumstances involved, a wide range of impacts have been found. Impacts range from an apparent negative one on agricultural production, where the area under crops fell by 52 percent on the project road and 44 percent on a control road,[6] to situations of very substantial impact, for example in the case of a new 85 km mountain road in Madagascar where rice production increased by 160 percent and coffee by 70 percent (Mitchell and Rakotonirina, 1977).

The impact of roads investment on the economy seems to depend upon a range of factors: (i) the magnitude of the change in transport costs, (ii) the competitive nature/current behavior of the transport and distribution markets, and (iii) the response of different parts of the economy to changes in transport costs and quality of transport (spillover effect).

Change in transport costs due to passability/impassability. Large changes in transport costs, per km, could occur with new construction if this involves a large proportionate change in trip length for diverted traffic or a change in transport mode, say from human or animal transport to truck. Much smaller changes in transport costs (per km) will occur with rehabilitation or maintenance. The HDM (Highway Development Model) road planning model is the main method of estimating changes in transport costs

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[6] A road without any intervention.

associated with road improvement. A change in impassability can have a major effect on transport costs that may have little to do with the 'impassable' distance. For example, a bridge over a river or a gorge can reduce the need for a very lengthy detour or the need for some other expensive transport solution. Weak soils, or an area prone to landslides, can make vehicle transport impassable during the wet season. In accessing a major market, a 20 km reduction in trip length, resulting from a new link, could give transport cost savings that are 20 times more than 5 km road maintenance improvement. Similarly, because human transport is so expensive, in much of the forest zone of West Africa where the alternatives are either head loading or truck transport, it has been estimated that converting a footpath to a navigable track, could change transport costs by over 100 times compared with the effect of upgrading the same length of track to a gravel standard road. (Hine, Riverson and Kwakye, 1983).

The competitive nature of transport and distribution markets. For transport cost reductions to have the maximum effect on other sectors of the economy, it is important for transport cost savings resulting from road improvements to be passed on to producers and consumers. In theory this depends upon the nature of competition among transporters and others involved in marketing and distribution. Concerns about the competitive nature of transport operators have long been recognized and most recently in a study on international corridors (Teravaninthorn and Raballand, 2008). A number of earlier studies have pointed high cost monopolistic transport operations in Africa for many years. Similarly there is also plenty of evidence of high marketing margins, restrictions of supply and other monopolistic food marketing practices in Africa (Romanik, 2007, Shepherd 2005, Balat et al. 2008). However, all this literature is based on the fact that it is assumed that production level may support competition, which may not be the case.

The response of different parts of the economy to changes in transport costs and quality of transport. A wide range of factors will influence how the economy will respond to changes in transport costs and charges.[7] Increases in personal mobility are

[7] The ability to respond to price changes depends upon the availability of underused resources of land, labor and capital. Clearly where underused land and labor are plentiful there is likely to be greater scope for agricultural production to respond to changes in transport costs. However where there is little spare

often the most noticeable change resulting from transport improvements. Reduced transport costs will often lead to an increased frequency and availability of transport services and, unlike freight transport, passenger mobility is not a derived demand, and hence often responds quickly with a high degree of price elasticity. Bulky low value commodities have, almost by definition, high transport intensity. Hence mineral production can be very sensitive to transport costs. However because of the necessary investment involved, there may be little response in the short run to transport improvements. Similarly bulky low value agricultural products such as sugar cane, coconuts and melons also have a comparatively high transport cost component of their final market price. However grain has a relatively high value to weight ratio and as a result there may be little impact on farm gate prices from reduced transport costs. For example, assuming all the transport cost reductions are passed on the farmer, it has been calculated, in an example from Ghana, that improving a 5 km earth road to gravel standard would only increase farm gate prices of maize by 0.1 percent (Hine, Riverson and Kwakye, 1983).

The nature of the response will also depend upon how transport cost savings are divided between transporters, middlemen, consumers and producers. Assuming that transport and distribution are competitive then the extent to which consumers and producers benefit from transport cost reductions depends upon the quantitative change in production and the elasticity of demand and supply in different markets. So following a roads investment an increase in the delivery to a small village or urban market may have the effect of reducing commodity prices at the market whilst only by increasing farm gate prices to a limited extent. In this instance the urban dwellers would gain significant benefits with perhaps little benefit going to the farmer. In contrast the same increase in delivery to a large urban market will have very little or no effect on urban market prices, and as result are much more likely to proportionately benefit the rural producers through an effective increase in farm gate prices.

In Uganda, contrary to some other countries in SSA, the government has invested heavily in the road sector, and especially in rural roads. However, due to the fact that

agricultural land, as for example in the mountainous areas of Nepal, the opportunity to respond may be very limited.

Uganda is still a predominant rural country, it was estimated by Carruthers et, al. (2008) that with a base scenario, Uganda should spend almost four percent of its GDP annually on roads (rural and non-rural) (see Table 1).

Despite investments, the RAI has not reached yet 30 percent in Uganda. Therefore, thousands of additional km of rural roads would need to be built in Uganda to achieve a rural access index of 100 percent.

Table 1: Level of Investment Needed to Meet Transport Targets of Base and Pragmatic Scenarios, by Country

Base scenario			Pragmatic scenario		
Group	**Country**	**%GDP**	**Group**	**Country**	**%GDP**
1	Congo, Dem. Rep.	25.1	1	Congo, Dem. Rep.	12.6
1	Niger	12.2	2	Niger	6.2
1	Chad	11.1	2	Chad	5.5
1	Mozambique	9.4	2	Mozambique	5.1
2	Zambia	7.5	2	Zambia	4.4
2	Malawi	6.3	3	Malawi	3.9
2	Namibia	5.6	3	Namibia	3.7
2	Burkina Faso	5.1	3	Tanzania	3.0
2	Ethiopia	5.0	3	Burkina Faso	2.8
2	Tanzania	4.9	3	Ethiopia	2.7
2	Madagascar	4.3	3	Benin	2.3
2	Sudan	4.0	3	Ghana	2.2
3	Benin	3.8	3	**Uganda**	**2.2**
3	Ghana	3.7	3	Sudan	2.1
3	**Uganda**	**3.6**	4	Madagascar	2.0
3	Senegal	3.5	4	Senegal	1.8
3	Cote d'Ivoire	2.6	4	Cote d'Ivoire	1.8
3	Cameroon	2.6	4	Rwanda	1.7
3	Kenya	2.5	4	Kenya	1.5
3	Rwanda	2.2	4	Cameroon	1.4
4	Nigeria	2.0	4	Nigeria	1.3
4	Lesotho	1.5	4	Lesotho	1.3
4	South Africa	0.6	4	South Africa	0.4

Source: Carruthers et al. 2008.

Based on extensive data collection in Uganda, it is demonstrated in this paper that investments in rural roads have a positive impact on farmers' income in Uganda (consistent with findings from Fan et al. 2004). However, based on our selected districts, reaching a RAI of 100 percent should not be a government objective for rural roads in Uganda because the expected benefit of such investment given existing transport patterns would be minimal, while the investments required to achieve it are unaffordable in Uganda. Taking into account the fact that plot size is limited to less than one hectare, the average farmer's transport requirement in Uganda is usually minimal.

The average farmer does not necessarily require massive investments in rural infrastructure from primary markets to the village, homestead or farm gate because they can neither afford to hire a truck nor load it sufficiently to break even if they could. Even if their agricultural productivity was significantly higher, most smallholder farmers could not approach the production threshold they would need to reach to justify hiring a truck.

Consequently, the main conclusions of the paper are the following:

(i) Rural transport policy and investments in Uganda should give more attention to the intermediate means of transport which allow farmers to take their crops from the farm gate to sell their production in local markets.

(ii) Subsequently, maintenance of existing rural roads rather than new roads should be given priority in most cases.

(iii) Policy makers should give attention to innovative marketing models from other countries such as India where smallholder loads are consolidated through consolidators.

(iv) An alternative objective and strategy is proposed, which would take into account much more strongly agricultural potential. We propose a two-pronged approach: first define the road allocation per district as a direct function of agricultural potential, contemplating the economic benefits of areas with strong agricultural potential, and second, minimal road connectivity would be defined per region such as connectivity at less than 8 or 10 km for Ugandan rural population.

(v) When implementing this methodology, it appears that roads rehabilitation could be done in some districts in the North and roads allocation should be reduced for some districts in the South West.

2. What should the objective of roads investment strategy be to ensure the highest benefits?

This section uses empirical analysis to test out some of the causal relationships set out in section 1. Integration of agricultural market prices, which were analyzed in the recent CEM (World Bank 2007), is not analyzed. Nor do we consider the impact on farmer incomes of multiple markets or options for sale (Barat et al. (2008) show that having more options increases sales and prices received).

Instead, we first use UNHS data to look at the relationships between:

(i) whether the household's share of their crop that is marketed increases per capita consumption - to answer the question of whether there are gains from trade;

(ii) whether household road access and proximity (distance, time use) to markets affects the share of households' crop that is marketed;

(iii) whether the mode of transport used to access markets (and the time taken) depends upon access to roads [triangulated with traffic counts];

(iv) whether there are remoteness effects on percentage marketed and mode of vehicle use to access markets.

The main conclusions are that there is an overall downward trend of consumption as people move further away from markets, with regards to both time and distance, and, on average, consumption is highest closer to the large cities/markets, but sharply declines for those households more than 4.5 km away. This would mean that road network expansion is in dire needs to reduce poverty.

However, the picture is more complex. It appears to be a **distance/transport time ceiling;** income generation is marginally more constrained beyond one to two days walking distance from the markets. Moreover, the mode of transportation does not really impact income.

Next unique household and transportation data in three selected districts, which was collected for this study, are analyzed to explore the relationship between alternative transport costs, transport prices, and the net profitability of taking crops to market with the modes of transport farm households most commonly use. Based on the pattern of costs, prices and modes of transport, we draw conclusions for public policy in the roads and transport sectors.

Uganda road network investment strategy

Uganda has a dense network of rural roads. Currently, the GOU guides the development of the entire road network in Uganda in line with the Road Sector Development Program (RSDP), which has two components: (i) the RSDP is a 15-year National Transport Master Plan (NMTP, issued in Nov. 2008) to be implemented by Uganda National Roads Authority (UNRA), and (ii) the Ten-Year District[8], Urban and Community Access Roads Investment Plan (DUCARIP, draft issued for discussion on March 2008), to be implemented by local governments, both rural (district) and urban authorities.

The two master plans, NMTP and DUCARIP, are conceived within Uganda's sector wide development policy, based on liberalization of the economy, decentralization of government and building capacity to sustain institutional initiatives.

The road network

The road network in Uganda is about 78,000 km comprising of:

- **National roads** (also known as trunk roads): 10,800 km of which 2,870 are bitumen standards and 7,930 km are gravel surfaced. National roads connect major towns and districts with one another and link Uganda to the neighboring countries; the national roads have expanded in size over the years, not by construction of new roads, but through re-classification of district roads into national roads network (e.g. the national road network was 9,300 km in 1996). The paved national road network has also expanded. In 1996 only 2,200 km or 24 percent of the national network was paved. Since then the paved network has expanded to 2,650 km by 2003 and 3,050 km by 2008. The length of paved national roads is expected to increase to 4,100 km by 2013, and to 7,100 by 2023. The 2023 figure would represent 37 percent of projected national network of 19,000 km.

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[8] Districts in Uganda were re-established starting 1997 through decentralization via devolution, with power to sue and be sued, and with authorities to plan, finance, administer, make bye laws and ordinances and as well as local administration of justice through Local Council Courts.

- District roads (also known as rural/feeder roads[9]): The district roads are about 27,500 km. This will reduce to 20,000 km due to re-classification and transfer of some 8,000 km to national road network. District roads are predominantly gravel and earth surfaced. About 12,322 km of district road network is in good condition, 6,161 km is in fair condition, and 8,939 km is in poor condition.

- Community access roads (also called economic roads) are small tracks and footpaths which link communities to social and trading centers, and connect to district and national roads. There are about 35,000 km of community access roads. Access roads are predominantly earth surface with carriage width ranging from 1 to 3 m. Access roads are the responsibilities of Local Council III Governments/sub-county governments, which are sub-division of district governments. No inventory has been taken on community access road condition. The estimated road network of 35,000 km was based on the assumption that links in the range of 2 to 5 km, and a sub-county has 8 to12 links.

Regional comparisons

Uganda is a country where the road density is among the highest in SSA, especially for secondary network and rural roads (see Table 2). The worst districts in Uganda are in a better position than most districts/counties in other countries (see Table 2 and the selected districts in Uganda[10]).

Table 2: Secondary Road Network Density (in km/1,000 km2)

	Density of Classified Roads	Density of All Roads	Secondary Density
Uganda	360	385	136
Rwanda	187	568	72
Malawi	141	165	71
Lesotho	175	196	50
Ghana	177	187	33
South Africa	167	300	31

[9] The district road network are classified into:

- Class I: 6.0 m width carriageway with 1.0 m wide shoulders;
- Class II: 5.0 m width carriageway with 1.0 m wide shoulders; and
- Class III: 4 m width with out shoulders. District roads are the responsibility of district local governments.

[10] For a brief overview of the selected districts, see annex 1.

Kenya	100	111	30
Tanzania	55	62	25
Cote d'Ivoire	80	82	24
Nigeria	135	174	23
Benin	75	142	21
Namibia	55	77	15
Madagascar	44	51	11
Cameroon	51	72	11
Senegal	81	94	10
Mozambique	37	61	6
Burkina Faso	27	39	6
Zambia	25	50	5
Ethiopia	21	46	5
Chad	22	27	5
Niger	11	13	2
Average	**96.48**	**138.19**	**28.18**
Median	**75.00**	**82.00**	**21.23**

Source: Carruthers et al. (2008).

The impact of road investment on road condition

The impact of the investment in the last 15 years has been substantial since the proportion of district roads from fair to good condition has increased (i.e. from 15 percent in 1990 to 65 percent in 2007). In the last 15 years, the GOU has made substantial investments in rehabilitation and maintenance of District, Urban and Community Access Roads (DUCAR), estimated at 740 billion Shillings (USD 400 million).

In 2007, the GOU established a road fund dedicated for improving the condition of road network. The government intentions are to fund part of the DUCARIP through the road fund, other funds as appropriated by the Parliament and contributions from the Development Partners. The government uses a Medium Term Expenditure Framework (MTEF) which sets sector spending ceilings within a three-year framework. However, there is currently a backlog of approximately 8,900 km of district roads, 3,600 km of urban roads and some 35,000 km of community access roads without appropriate financing.

The next question is: What is the economic impact of high rural road density in Uganda?

The impact of roads investment on agricultural production

Based on our household surveys in our three selected districts, the main findings are the following: (i) the 2 km distance from a road is not an economic threshold (beyond or above 2 km from a road does not necessarily have a positive impact on household income), (ii) bike ownership also does not have the expected positive impact (probably due to the low value of time[11]), and (iii) road passability also does not have a major impact when it is minimal (because when walking, road passability should be minimal). What seems to matter for increased income is yield, crop type, which means growing high-value crops, selling directly products to markets and increased rural roads density.

There are indications in the literature that a ‘one size fits all approach’ is not effective in addressing the problems of African countries. “In some countries large sums of money have been wasted in building roads to high geometric standards with excessive carriageway widths for these low volumes of traffic (Ellis and Hine, 1998).” Instead, countries may need to adapt an approach that supplies the appropriate road for a rural area, realizing that a large main road may not be required. Fan et al. (2004) first found a significant impact of roads on rural poverty reduction; the study then drilled down further to differentiate the effects of different types of roads. The authors found that low-grade feeder roads had a greater impact on poverty than murram or tarmac roads. In this case, feeder roads led to increased agricultural productivity, which works to reduce poverty in rural Uganda. There is other evidence from Uganda that supports the importance of smaller roads. Growth regressions demonstrate that distance to feeder roads, and not main roads, has a positive effect on per capita consumption in rural areas (Schipper et al. 2007).

[11] Mainly because the median distance is less than 5 kilometers and the bicycle, when loaded, could be pushed.

An analysis based on UNS household surveys

This part is a summary of the results of the analysis conducted to determine the relationships between time and households consumption in Uganda[12].

The first element to select was the type of market to evaluate. The survey had three main categories of markets, agricultural producers' market, agricultural inputs market, and consumers market, with different types within each (most common, periodic, general, cooperative, and others). Upon examination there was a high correlation between agricultural producers' and inputs markets; in 89 percent of the cases a community either had both or neither market, allowing evaluation of one market to be representative of both.[13]

However, the design of the survey restricted evaluation of the time to markets. The survey asked local community members whether a certain type of market existed in their community. If they responded no, questions were then asked about where the closest market was located (distance, common mode of transport and time to the closest market). However, if the community answered yes, they did have that type of market in their community the surveyor moved on to the next type of market. The result of this questioning limited the evaluation as there did not exist data for those living with the type of market in their community.[14] [15] Figure 1 provides a picture of what does occur.

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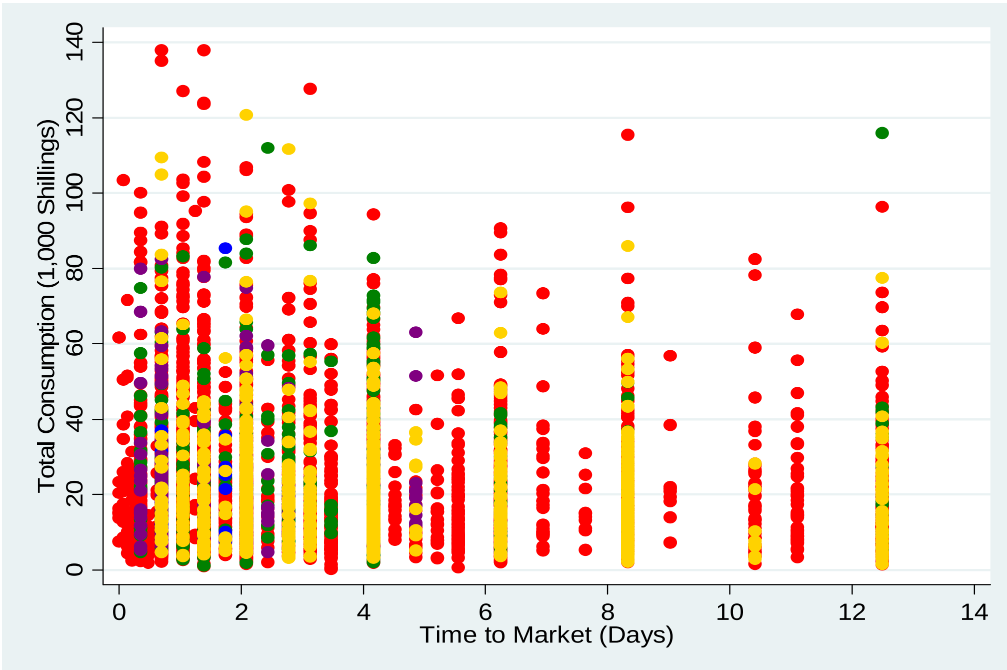
[12] The study utilized the Uganda National Household survey from 2005/06 that was performed by the Uganda Bureau of Statistics (UBOS). Two elements from this surveyed were drawn on, the household socio-economic portion, containing 7,426 households, and the community level portion, administered in 706 communities. The first steps were to determine the proper measure of consumption and which markets to measure, as they were multiple options for each (see annex 2 for definitions). Note that consumption (and not income) was used because income may be more difficult to accurately measure than consumption. Various consumption measures were provided in this survey, food and beverage consumption over the past 7 days, non-durable goods and services consumption over the last 30 days, semi-durable goods over the past 365 days, and a measure of consumption expenditure per adult. The decision was made to employ the food and beverage consumption measure as it had the shortest recall period and was representative of the overall households' consumption.

[13] A similar correlation was found between producers' and consumers' markets, as well as inputs and consumers' markets.

[14] The goal of this exercise is to determine the breaking point in which distance affects significantly income. If a household lives close to a market, we assume that the walking distance is low and no variation in income will be found.

[15] In addition, there were inconsistencies in the data, with communities reporting time and distances that did not seem sensible. Some communities reported being 0 kilometers from the markets, but took them 1,000 minutes to arrive to the market, or it took on some communities 200 minutes to walk 20 kilometers, while it took 1,000 minutes for another community to walk the same distance. Though there is the possibility of differing terrain, there were also communities

Figure 1 : Consumption Compared to the Time to General Agricultural Producers' Market



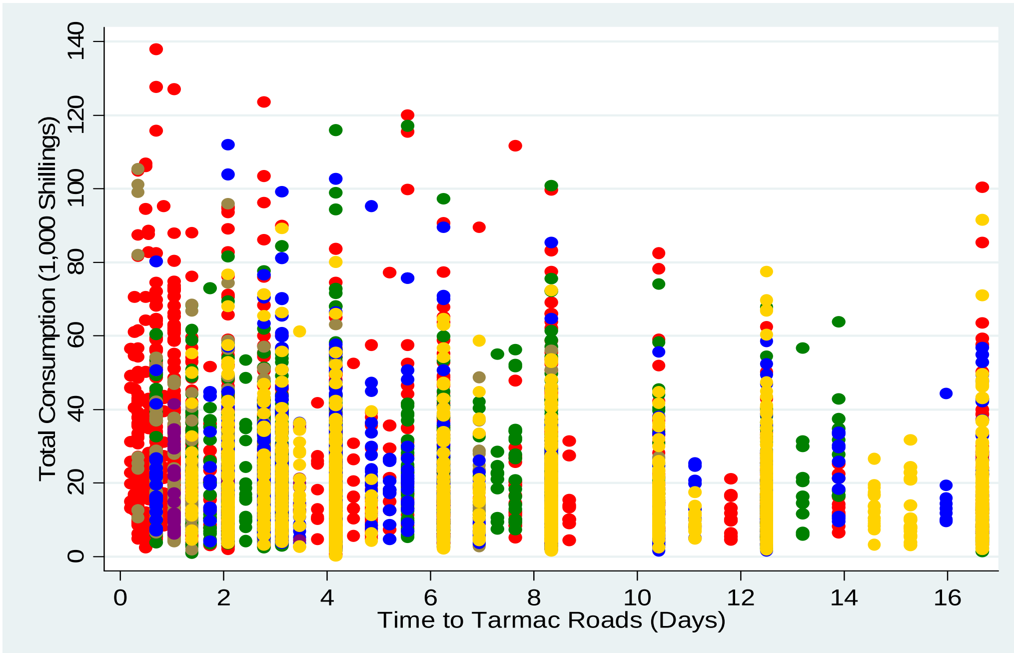
Note: Red represents walk, green taxi, blue bus, purple motorcycle, gold bicycle, and brown boda-boda. The upper five percent of time to market and of total consumption dropped

The community survey also provided another element to compare results, access to paved roads. Logically it was thought that paved roads lead to cities and/or markets, allowing this to serve as a proxy to further support the results of the first graphs. Again the surveyor asked if there was access to a paved (tarmac) road within the local community[16]. This portion of the survey suffered from some of the same issues the section on markets did. Nonetheless, a comparison was still made between time to the paved road and consumption of the households; the results are presented in Figure 2.

that reported a travel time of 60,000 minutes, which is 1,000 hours or a little more than 40 days. To combat some of these discrepancies the analysis was conducted on a trimmed sample, the upper 5 percent of the time sample was dropped. Additionally, to make the data more manageable and more readable, the time to market was converted from minutes to hours than to days.

[16] If the answer was no then information was collected on closest location to next paved road, time, common transportation method and time to the road.

Figure 2: Consumption Compared to the Time to a Paved Road



Note: Red represents walk, green taxi, blue bus, purple motorcycle, gold bicycle, and brown boda-boda; The upper 5 percent of time to market and of total consumption dropped.

From these graphs different conclusions about time to markets can be drawn. An overall trend across all the graphs is an obvious downward slope of the data. This suggests a negative relationship between the two components: long distance to the market (or to the paved road) is related to less consumption.

Secondly, the mode of transportation does not vary much with distance or income. Figures 1 and 2 show low consumption households at great distance from the markets when walking, in addition to the wealthier ones that live closer. Bikes, motorcycles, taxis, buses, and boda-bodas (bike taxis) also appear to be time and income invariant. Therefore, in Uganda there does not appear to be a relationship between the mode of transportation and the consumption of the household or the time to market.

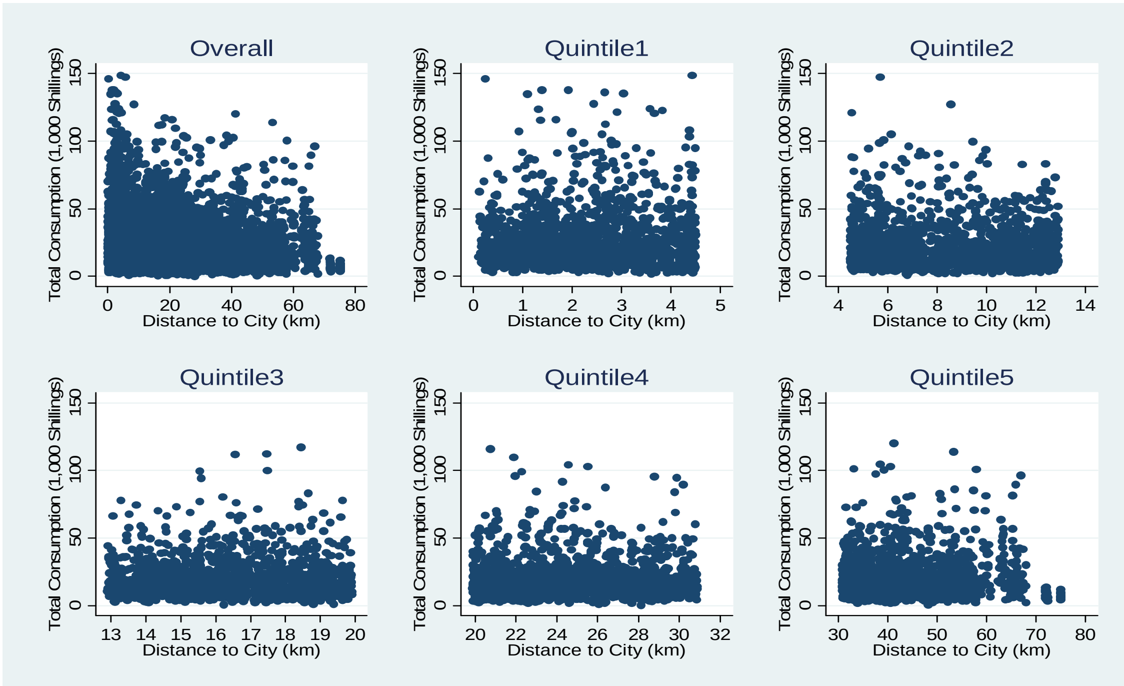
Thirdly, from Figures 1 and 2 one can observe a **time ceiling** on consumption of households. Around day 5 there are no observations, except two outliers, at or greater than 100,000 Shillings. Then around day seven there are but a dozen households that are greater than 60,000 Shillings of consumption. This consumption ceiling buttresses the relationship between time and consumption; implying that after a certain time away from the market or a paved road (that possibly leads to the market), people no longer have the ability to generate as much income, leading to less consumption by the household.

In a final approach it was thought that if the proper distance could be calculated between the households and the markets a better understanding of the relationship between consumption and remoteness could be understood. The survey did provide GPS coordinates for the households, the center of the community, and the common consumer market. However, issues arose when dealing with the GPS coordinates, not all of the coordinates were recorded in the same format or properly. This required cleaning the household coordinates, unfortunately, the time consuming manner of this did not allow for the same to be done for the village or the market coordinates (see Annex 3 for assumptions). As a second best approach, the households were connected to the nearest large city (over 2,000 inhabitants, resulting in 68 cities across the country) and the Euclidean distance was calculated.[17] The reasoning for this approach was that though there may be other markets that are closer, a large city will have all of those markets and will allow consumers and farmers to purchase all of their needs at once.

The distance of each household to the city was then compared to the consumption of the household, providing a more accurate and precise measurement than before. To give an overall picture the households were broken down by quintiles of distance to the city/market, Figure 3. For the overall graph the downward trend is again apparent (for more details see Annex 4). The most important point to note is the large drop in consumption between the first quintile and the second quintile. After 4.5 km from a large city/market the consumption of the household drops greatly, and more than it changes between any other two quintiles after that. This finding is consistent with with Stifel and Minten (2008).

[17] Estimates of the distance to the markets and the road were given in the community survey, but as noted above the inconsistencies made these measurements unreliable.

Figure 3: Food and Beverage Consumption Compared to the Distance to the Nearest City



An analysis based on household surveys[18] in three Ugandan districts

Table 3 presents some determinants of household income derived from agricultural products sales. The main transport-related findings are of great interest and could seem paradoxical. Indeed, the 2 km distance from a road is not an economic threshold because beyond or above 2 km from a road is never a significant determinant factor of this income. Moreover, bike ownership does not have the expected positive impact on revenues derived from sales of agricultural products[19] (probably due to relatively low value of time[20]) and road passability also does not have a major impact when it is minimal (because when walking, road passability should be minimal).

High yield, high-value crops and selling direct to market is what matters. What seems to matter for increased income (consumption) is yield, crop type (which means

[18] For variable definitions, see annex 5. These surveys were conducted in December 2008 and January 2009.

[19] It may have some impact on non-farming economies but it is not captured in the regression.

[20] Mainly because the median distance is less than 5 kilometers and the bicycle, when loaded, is pushed.

growing high-value crops), selling directly products to markets (sell direct) and increased rural roads density.

Table 3: Transport Determinants of Income Derived from Agricultural Sales

Dependent variable: income ('0,000 Shillings)					
	Basic (1)	Controls (2)	Density (3)	Tororo (4)	Greater than 2km (5)
Sell direct	**150.638*** **	**144.447*** **	**148.927*** **	**124.201*** **	**126.209*** **
	(39.679)	(40.170)	(39.805)	(39.235)	(39.326)
Crop type	**122.013** **	61.243	95.355	**257.234*** **	**249.087*** **
	(59.587)	(62.682)	(62.990)	(77.457)	(78.050)
Yield	**0.176*** **	**0.187*** **	**0.207*** **	**0.218*** **	**0.219*** **
	(0.058)	(0.058)	(0.059)	(0.057)	(0.057)
HH size		1.636	2.951	3.239	2.869
		(3.625)	(3.658)	(3.543)	(3.570)
Secondary		**16.303** **	8.304	6.09	5.584
		(6.256)	(7.143)	(6.949)	(6.977)
Gender of head		61.288	39.307	18.331	11.391
		(42.884)	(43.044)	(42.145)	(42.890)
# of bikes owned			27.646	22.141	21.175
			(22.737)	(22.081)	(22.123)
Passability			-0.604	0.001	-0.046
			(0.532)	(0.545)	(0.548)
Road density			**440.951***	**680.394*** **	**693.383*** **
			(247.416)	(249.809)	(250.403)
Tororo				**127.105*** **	**123.665*** **
				(37.474)	(37.699)
Greater than 2km					22.574
					(25.407)
Constant	3.078	-74.553	-153.226**	-291.41***	-288.192***
	(24.811)	(51.275)	(65.691)	(75.549)	(75.686)
# of obs.	173	170	169	169	169
R2	0.2209	0.2631	0.3021	0.3494	0.3527
Significance: 10%*, 5%**, 1%***. Note: Standard deviation in parenthesis.					

The low impact of living inside the 2 kilometer buffer.[21] The apparent paradox lies in the fact that increased rural roads density has a positive impact on incomes but not the 2 kilometer buffer. Therefore, some minimal road access is needed to impact economically

[21] As mentioned before, the Rural Access Index measures household remoteness to more than 2 kilometers from an all season road. By 2 kilometer buffer, we consider the 2 kilometer bands to each side of the road.

income generation but investing to have rural population at less than 2 km may be considered as overinvestment (in our selected districts)[22]. It will be demonstrated in the next section that the 2 km buffer has a minimal positive impact on income due to low plot size; increased road density does not create an expanded transport requirement for most farmers. Moreover, sustainability of such investments is at stake and therefore, roads investment strategy should probably be better adjusted to farmers' transport requirements.

3. What is the transport requirement from a farmer's and trader's perspective?

In rural areas in Uganda, most farmers produce between 400 kilos and 3 tons (per year) depending on commodities, soil fertility, inputs and other factors. In the case of most crops, taking into account that the average grown area which is, in most cases, around 1 hectare in Uganda, not more than 100-200 kilos are to be transported per week; therefore, except in special cases, a farmer only requires transport by bicycle or motorcycle.[23] If crop selling price is low, the current production make walking and selling crops directly to local markets the most profitable option and then does not necessarily require roads investment for trucks, at least for the last mile.

The farmer's perspective

Analysis of transportation methods in SSA conclude that intermediate transport, such as bicycles, motorcycles, handcarts, and animals, are vital in connecting people with markets (Starkey 2001). This connection enables people in remote areas to bring (more of) their crops to market while decreasing the costs and time of transport.

[22] This finding is consistent with World Bank (2009.2). This research centered on Malawi finds out that the optimal transport time for higher agricultural growth is 2.2 hours. Assuming walking or bicycle at 4 kilometers per hour, the optimal transport distance for agricultural production from a road would then be over 8 kilometers (from an economic point of view).

[23] This information comes from our household surveys. The UNHS does not have information about individual travel or mode of travel with crops to market. The USHS has information about the assets owned by the household (including bicycles), but we do not know what mode they are using to or how they transport their crops or how far/long they travel. The UNHS does ask for the most common mode of transportation from the village to the market, but this is at the community level, so connecting it to the type of crops grown or the amount sold would be a generalization at best and unreliable.

The following sections are based on data collection carried out in Masindi, Bushenyi and Tororo districts in 2008/2009 and confirm that current production volumes and yields only make economically viable transport by bicycle and/or motorcycle in most cases. Explicitly, volume is the critical factor in determining mechanization and in the case of Uganda, the current volume marketed is too low. This finding is especially critical to design the infrastructure requirement for farmers to be linked to markets and, in most cases, it can explain, despite a rural road, transport by truck is not much needed. Transport per truck can be only economically viable for high value products, over a relatively long distance (50 km) and with consolidated production (i.e., through an integrated company such as a cotton company which does organize transport or through cooperative mechanisms).

Transport by truck is indeed, by far, the cheapest mode of transport (per ton-kilometer): almost ten times less expensive than bicycles and eight times less expensive than motorcycles (see Table 4). However, the story is more complex because per kilometer, transport by truck is more 10 times more expensive than bicycles and motorcycles.[24] It is also worth noting that when operating costs account for the bulk of total transport costs per truck, financing costs, and even more value of time, are the most important cost factor for bicycles and motorcycles, which means that operating costs are minimal.

Table 4: Transport Costs per Mode of Transport (in US cents per tkm)

Bicycle	105.9
Motorcycle	95.9
Truck	11.2

Note: mean load is 60 kilograms for bicycles, 110 kilograms for motorcycles and 10 tons for trucks. Value of time is included for bicycles and motorcycles; 1 hour is considered as the average transport time for bicycles (4 km) and 1,5 h for motorcycles (25 km).
Source: surveys and DFID (2005) for the value of time.

Obviously, commodities selling prices differ from regions and between them. Therefore, the transport constraint may not be so strong for high value products. In the

[24] See annex 6 for a detailed statistical description of the fixed and variable costs of different means of transport.

selected districts, the selling price of cassava starts from 300 Shillings per kilogram and the highest selling price is for beans (in Tororo district) with 1,500 Shillings per kilogram.

Based on various selling prices (low, medium and high), the difference between sales and transport costs per mode of transport for different distances and tonnages is computed. Unsurprisingly, for one ton and 50 km transported, the margin is the highest for a truck (actually the other modes of transport are not suitable); even more interesting is the fact that for 110 kilos, transport by motorcycle is more profitable than transport by truck and for 60 kilos, transport by bicycle is always the most profitable (see Table 5).

It is therefore time to know, from a farmer's perspective, what is their average output to better understand how it is more likely to export 60 kilograms, 110 kilograms or 1 ton each time they have need transport.

Table 5: Difference Between Sales of Agricultural Products (at the local price) and Transport Costs per Mode of Transport, Commodity Value, Distance and Tonnage (in USD)

Transport 60 kilos, 10 kms	Low value	Medium value	High value
Bicycle	8.5	19.2	45.2
Motorcycle	8.1	18.8	44.7
Truck	-2.1	8.6	34.6
Transport 110 kilos, 10 kms	**Low**	**Medium**	**High**
Bicycle	n/a		
Motorcycle	15.7	35.3	82.9
Truck	5.6	25.2	72.7
Transport 1 ton, 50 kms	**Low**	**Medium**	**High**
Bicycle	n/a		
Motorcycle	n/a		
Truck	96.6	274.7	707.3

Notes: Low commodity selling price (cassava) is declared at 300 Shillings per kilogram, medium commodity selling price (maize in Tororo district) is declared at 650 Shillings per kilogram, high commodity selling price (beans in Tororo district) is declared at 1,500 Shillings per kilogram. Transport costs include the value of time.

In rural areas in Uganda, most farmers produce between 400 kilos and 3 tons of crops depending on commodities, soil fertility, inputs and other factors. In the case of perennial crops such as bananas, on average, up to 300 kilos are supposed to be transported per month, which means a truck cannot be full loaded per farmer and the most profitable option is probably a motorcycle; for other commodities, taking into account that the average grown area is, in most cases, around 1 hectare in Uganda, not more than 100-200 kilos are to be transported per week; therefore, except in special cases, an individual farmer only requires transport per bicycle or motorcycle.[25]

From a farmer perspective, the final question is to know if the usual return enables them to purchase a bicycle or motorcycle because with the current average production, farmers can afford to pay operating and depreciation costs for bicycles and motorcycles. Table 6 demonstrates that unless a farmer has financing possibilities or existing cash flow, a motorcycle in most cases is not affordable and a bicycle is only if the crop selling price is not too low.[26]

Table 6: Share of Bicycle and Motorcycle Initial Cost Compared to the Selling Price of one Ton of Selected Commodities

	Low value	Medium value	High value
Bicycle	29%	14%	6%
Motorcycle	655%	302%	131%

Note: USD 45 is the average price for a bicycle and USD 1,000 for a motorcycle in Uganda.

The main implication for road planning and design is that, in most cases, infrastructure for bicycles and motorcycles in rural areas is sufficient to link economically farmers and the first market. For a farmer producing low quantities and without cash to purchase a means of transport, transport per bicycle is the cheapest mode of transportation; for a vast majority of farmers, they cannot load a 5 ton truck and do not have the cash to pay for USD30 (which is over 15 times more expensive than bicycle and 10 times than motorcycles, see Table 7). Therefore, it does explain why trucks are hardly

[25] It is obvious that higher selling price and consolidation of loads among farmers make more likely transport per truck over a long distance.
[26] On top of transport costs, the farmer needs to add input costs, such as seeds, fertilizers, and pesticides (although the later are hardly used by most farmers).

seen on many rural roads. Because of cash scarcity and low production, the transport by truck is the least economical mode of transportation for most farmers. However, transport by bicycle is sometimes impossible because of climate, terrain and so on.

Table 7: Transport Price per Mode of Transport and Distance

Distance to Tororo Market (km)	Commodities	Bicycle 60 kg per trip	Motorcycle 110 kg per trip	Pick-up 1 ton per trip	Lorry 5 to 7 tons per trip
8	Ground-nuts, fruits	3,000	5,000	15,000	50,000
5	Rice, maize	2,000	5,000	15,000	40,000
14	Onion, millet, tobacco	4,000	7,000	30,000	50,000
14	Onion	4,000	7,000	30,000	50,000
20	Pineapple, fruits, oranges, mangoes	5,000	7,000	40,000	80,000
23	Rice, pineapples, groundnuts	5,000	8,000	55,000	100,000

The service provider and trader's perspective

Transport costs and transport prices. It is also worth noting that despite the fact that transport by bicycle is cheap, the margin between prices and costs is by far the highest, which also explain why transport services (by bicycle and motorcycle) has flourished in many rural areas (see Table 8). In a rural region, for a household with minimal cash, investing in a bicycle can be profitable (whereas motorcycle necessitates more cash flow from farm activities).

Margins of transport by truck are comparable to motorcycle and higher, which corroborates the fact that truckers/traders use their market power to set prices at levels with comfortable margins (more than USD3 per kilometer).

Table 8: Ratio Between Transport Price and Costs in the Selected Districts

Bicycle	7.5
Motorcycle	2.6
Truck	2.1

Note: transport costs prices for bicycles and motorcycles include the opportunity cost of the driver.

Consolidation of loads. However, it is also worth taking into account the fact risk in rural areas is higher than on corridors because of possible very low volumes and impassability. Without 250/500 kilos, running a truck over 50 km in rural areas is not profitable at all. Using trucking services starts to be really profitable for the trader from 500 kilos of load (see Table 9). That is also why, consolidation of loads is so critical for a trader: without consolidation, the needed discounted selling price is so high than most farmers are interested in selling their small quantities to traders. At the farmer average production level, transport or marketing margins are high to compensate a lack of economies of scale.

Table 9: Selling Price Discount Needed to Compensate Operating Costs for a Truck for Various Quantities and Commodity Values

10 km, old truck	**60 kilos**	**110 kilos**	**250 kilos**	**500 kilos**	**1,000 kilos**
Low value	**100%**	**67%**	**29%**	**15%**	**7%**
Medium value	**57%**	**31%**	**14%**	**7%**	**3%**
High value	**24%**	**13%**	**6%**	**3%**	**1%**
10 km, new truck					
Low value	**100%**	**100%**	**46%**	**23%**	**11%**
Medium value	**88%**	**48%**	**21%**	**11%**	**5%**
High value	**38%**	**21%**	**9%**	**5%**	**2%**
50 km, old truck					
Low value	**100%**	**100%**	**100%**	**73%**	**37%**
Medium value	**100%**	**100%**	**68%**	**34%**	**17%**
High value	**100%**	**67%**	**29%**	**15%**	**7%**
50 km, new truck					
Low value	**100%**	**100%**	**100%**	**100%**	**57%**
Medium value	**100%**	**100%**	**100%**	**53%**	**26%**
High value	**100%**	**100%**	**46%**	**23%**	**11%**

What would be the transport requirement in case of dramatic increased production?

In case of significant increase of agricultural productivity, with an average of 1 hectare per household, annual production would hardly reach 8-10 tonnes, which is at least 3 to 4 times the current production (see Table 10). However, in terms of transport demand, this is still not equivalent to a truckload per year. Therefore, even though a season would last only a couple of months, the transport equivalent would be limited to 300-400 kilogrammes per week, which means that infrastructure-wise, a paved, all-weather road would not be necessarily needed and IMTs[27], with appropriate infrastructure, could bridge the last mile gap.

Table 10: Actual and potential yield per household in selected districts in Uganda (in kgs)

District	Crop	Actual	Potential	*Ratio potential/actual production*
Bushenyi	Bananas	960	6,719	*7.0*
	Beans	200	683	*3.4*
Tororo	Cassava	19,000	41,503	*2.2*

Note: actual data extracted from household surveys; potential data derived from FAO model.

It brings data to what Metschies (1998) had already pointed out: infrastructure and transport services requirements are correlated with agriculture type. For small shareholders based, who depend on subsistence agriculture, agricultural surplus is so low that it cannot lead to transportation by truck and therefore the infrastructure requirement should be limited to fulfill IMTs demand. In the case of larger plot sizes (and increased productivity) and even better mechanized agriculture, roads are needed for trucks.

[27] Intermediate means of transport (IMT) can increase the carrying capacity and speed, reducing transport costs. If markets are too far to walk (one way 10 – 15 km) is often regarded as the threshold for access to markets. A pack animal can extend the distance to 20 km in hilly areas, a bicycle to 30 km in flat terrain and a single-axle tractor with trailer covers up to 50 km (Hine and Ellis, 2001). Thus, IMT make new markets accessible where producer prices might be higher; new products might be demanded, or inputs might be cheaper. For long distances the use of motor vehicles is essential.

The remaining section is then to know if the current strategy to invest massively in rural roads is sustainable in the short and medium term.

4. How much to invest in roads to ensure rural growth? The public policy perspective

As stated in the previous section, mechanization in Uganda is not widespread because average plot size is small and consolidation does not take place (on top of a lack of investments). The GOU adopted an ambitious investment plan for rural roads. However, regarding investment in roads to ensure rural growth, constructing or maintaining roads in areas with high agriculture potential is a recommended policy. For the time being, there is strong disconnect between the funds allocations to maintain rural roads and agriculture potential despite official discourses.

In March 2008, a *Ten-Year District, Urban and Community Access Roads Investment Plan* (DUCARIP) with a corresponding financing plan was announced. In the upcoming ten years, GOU has committed itself to invest a total of 1,594 billion Shillings or USD862 million, of which 953 billion Shillings for district roads for ten years from fiscal year 2008/09 to fiscal year 2017/2018. Over the medium term, 2008/09 to 2012/13, the estimated shortfall in financing the medium-term investment plan for both DUCARIP and MTEF is around 365.5 billion Shillings (USD197.7 million equivalents; see Table 11 for details).

Table 11: Financing Plan of the Medium Term Expenditure (in billion Shillings)

Expenditure estimates	**2008/09**	**2009/10**	**2010/11**	**2011/12**	**2012/13**	**Total**
DUCARIP projection	125.5	141.2	156.9	174.2	171.7	769.5
MTEF projections	55.8	75.8	90.8	90.8	90.8	404
Shortfall	69.7	65.4	66.1	83.4	80.9	365.5

Source: MOFPED MTEF Ceiling FY 2007/08 – FY2012/13.

Current low efficiency of spending and incentives to expand rural roads network

Because this plan entails further massive investments in rural roads, it is crucial to know if the current investments are achieved according to road condition and agricultural potential. Indeed, if allocation to roads maintenance is assigned independently of road condition, future roads investments may face the same problem of spending efficiency. Based on reliable and extensive data per district, unfortunately, Table 12 (and Figure 4 at the district level) demonstrate that road condition, district area do not explain why some districts benefits from higher funding than others. Taking into account the extremely high correlation between network length and allocation for roads maintenance, one can assume that there is a formula based on network length to define the allocation per district. Finally, it is worth noting that this allocation is probably adjusted with some political factors; indeed, the number of constituents in the Parliament seems to have an impact on the amount allocated for roads maintenance.

Due to the current investment strategy in rural roads, it seems better for a local authority to expand its network than maintain it due to the fact that increased allocation probably mainly depends on the network length and can explain why local authorities now strive to upgrade many community roads to district roads.[28]

[28] However, this incentive can have a negative impact on the network sustainability (which is developed below in this chapter).

Table 12: Main Determinants of Spending for Rural Roads

Dependent variable: Released funds for feeder roads maintenance in 2006 (per capita)														
	(1)		**(2)**		**(3)**		**(4)**		**(5)**		**(6)**		**(7)**	
Road condition	1.44		1.2		-5.08								2.93	
	3.11		*3.14*		*5.18*								*3.44*	
Network length per capita	**4.71E+05**	**	**4.74E+05**	**			**4.85E+05**	**					**4.81E+05**	**
	5.19E+04		*5.17E+04*				*4.71E+04*						*5.37E+04*	
Number of constituents per capita	3.89E+06								**1.86E+07**	**			5.38E+06	
	4.29E+06								*6.37E+06*				*4.36E+06*	
Number of NRM constituents per capita			4.23E+06								**2.00E+07**	**		
			5.19E+06								*7.88E+06*			
Area	0.01		0.01										0.01	
	0.01		*0.01*										*0.01*	
Poverty rate													2.07	
													2.23	
Constant	-3.25		5.46		**738.64**	**	97.7		**431.67**	**	**488.78**	**	-127.08	
	101.35		*99.79*		*97.04*		*62.46*		*92.12*		*83.47*		*174.94*	
# of obs.	55		55		55		55		55		55		52	
R^2	0.68		0.68		0.02		0.66		0.14		0.11		0.70	

Notes: (**) implies significance at the 5 percent level and (*) at the 10 percent level. Standard error is reported in italics.

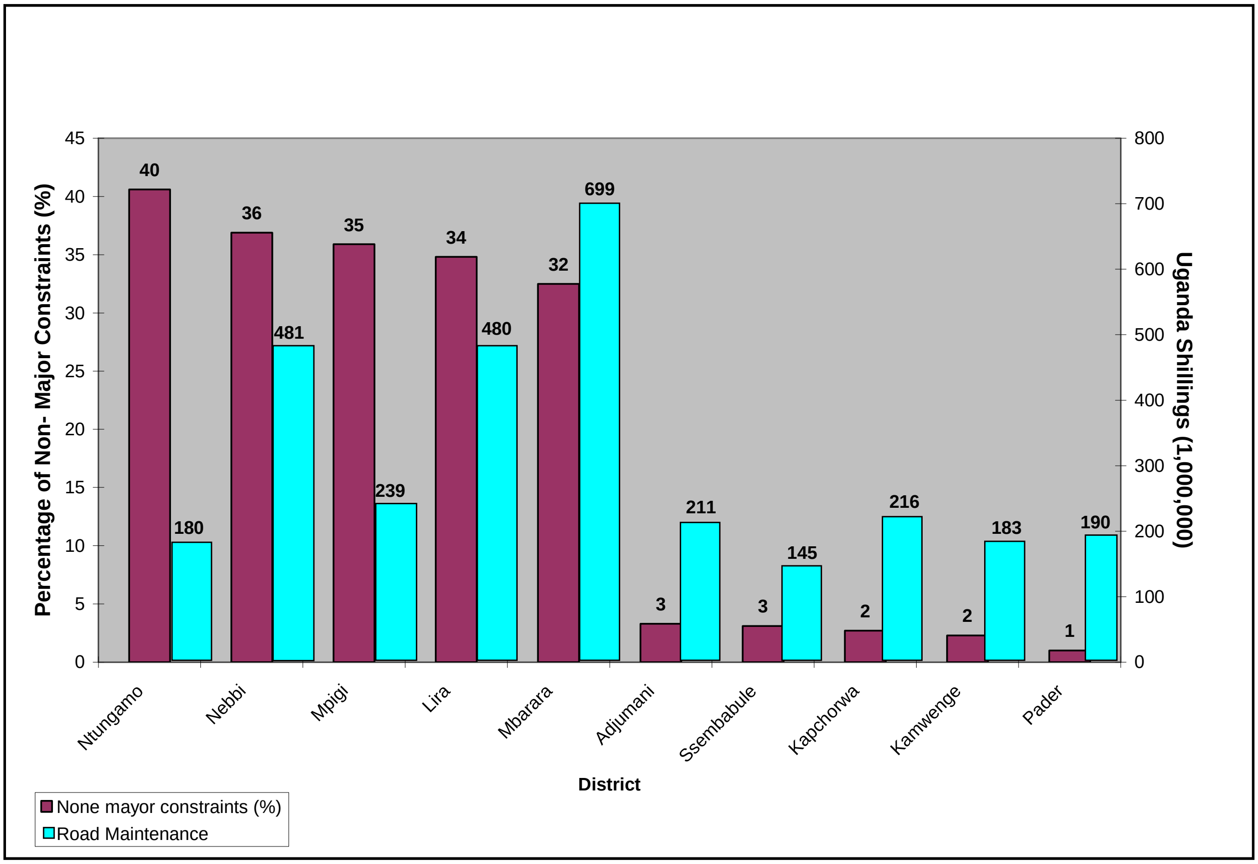
On the link between spending in roads and agricultural potential, results are similar: despite statements, agricultural potential [29] does not appear to be a major consideration when allocating the road maintenance budget in Uganda.[30] Using the 2006 figures of the amount of money released to the districts under the heading of Road Maintenance Conditional Grants, a simple correlation test was run with the agricultural potential data. The results show that there is no correlation between the agricultural output of a district and the amount of road grants received: 0.05 for the correlation coefficient between coffee potential and road grants 0.05; -0.02 between cotton potential

[29] See annex 7 for details on the methodology.

[30] The DUCARIP does not address the agricultural potential subject nor mention agricultural potential as a factor determining road intervention. However it does say "Implementation of DUCARIP will entail close collaboration between MOWT and MFPED. Programs supported by Development Partners like PMA (Plan for Modernization of Agriculture) will require liaison and coordination with other stakeholders, e.g. Ministry of Agricultural..." ("The Ten-Year District, Urban and Community Access Roads Investment Plan (Draft)," Ministry of Works and Transport , 2008, page 23 http://www.roadfund.ug/Resources%20Files/DUCARIP-FinalDraft-19.02.2008.pdf

and road grants; 0.02 between maize potential and road grants; and -0.04 between soy bean potential and road grants. Following figures visually represents the lack of correlation between potential output and road grants in Uganda. Regarding coffee, the Kitgum district has the second highest potential output, but receives less than the three lowest potential districts, Mukono, Wakiso, and Tororo, who each have the potential of only 1,000,000 kilograms of coffee.

Figure 4: Road condition compared to road maintenance funds of selected districts in Uganda



Source: Ministry of Finance, Planning and Economic Development. Data sorted by percentage of roads none considered as a major constraint by household interviewed.

In addition, to comparing the weight of the agricultural potential to the allocation of road maintenance grants, comparison of agricultural potential value is also possible, using international prices, provided by the Uganda Export Promotion Board, local prices, as obtained from the household surveys.[31] One can easily see the differences in the export and the local/household prices, the comparison of prices supports findings that exportation can aid in alleviating poverty because of the higher prices found on the international market.[32] If road budget allocation does not consider agricultural potential than financially lucrative opportunities may be missed out on. The prices from Table 13, were multiplied by the agricultural potential of that crop, resulting in the potential value of the crop.[33]

Table 13: Crop Price Chart: Export and Local Price

Crop	Export price (per kg)	Household price (per kg)
Coffee	$1.62	$0.51
Cotton	$1.21	$0.41
Maize	$0.24	$0.26
Soy bean	$0.23	$0.10

Note: Export price and household price are based on 2007 exchange rate.

If a district has the financial means to improve its road network then that district has a greater opportunity to sell its agriculture output. For example, if the district of Masindi decided to reach its coffee potential of 107,658,952 kg, then with an improved road system they could sell that coffee at the local market for USD54 million or export for a total of USD174 million. Or if the Pader district in North Uganda chose to grow its

[31] The prices from the Uganda Export Promotion Board are calculated by dividing the total value of the export for 2007 by the total weight exported, resulting in a price per kilogram in US dollars. Reference: http://www.ugandaexportsonline.com/statistics.htm. For the household surveys, the median price of the crop when it was sold at the market (not to a trader) was used. However, the prices from the household data are in Uganda Shillings. To convert from Shillings to dollars, we collected data on the exchange rate over the month of December 2008 (the month when the household data was collected) and used the average as the exchange rate, 1,960 Shillings per dollar. The road maintenance data has also been converted from Shillings to dollars using an average of the 2006 exchange rate, for a rate of 1,830 Shillings per dollar.

[32] In the case of maize, the local price is higher than the international price. This may be due to maize's position as a staple in Ugandan diet, as well as the large swings in prices. The household data gave a range from 150 Shillings. (USD 0.08) to 5,000 Shillings. (USD 2.55) per kilogram.

[33] There is always the possibility that households are consuming some of the output and that not all of the potential output is going to the market.

potential cotton output of 70,426,704 kg, the result would be USD 28 million if sold at the local markets or USD 85 million if exported.[34]

The potential value of these crops is compared to the road maintenance allocation of district in Uganda in Figures 5 and 6. Potential output in international and local prices is presented on the left vertical axis and the amount of road maintenance grant on the right vertical access. Note that the agriculture potential is in millions of dollars, while road maintenance is in thousands of dollars. Again, only a subsample is provided, including the five largest and smallest potential producing districts. The Nakapiripirit district has the potential to generate almost USD1 billion from coffee at international prices, but receives less than half the road allocation that Jina, a district that has little potential to produce one of Uganda's largest exports, receives. Figure 5 shows that even though Kotido has the potential to produce three times the maize of Arua, they are allocated almost the same amount in road maintenance grants.

[34] The differences in output between districts may appear drastic and unreasonable, but these differences are related to a number of factors. Firstly, the calculations are based on the average potential yield per hectare multiplied by the sum of the total potential area in hectares. Therefore, these graphs are not comparing the output per hectare (yield), but the potential output of a district if every potential hectare was devoted to the production of that single crop. As a result of this, there are large differences between districts, largely due to differences in the size of the district. A simple visual analysis of a district map of Uganda shows many small districts in the central, western and eastern regions, while in the north there are fewer districts that cover much larger areas. For example, Kotido in the north has a much larger potential coffee output than Tororo in the east. The GAEZ calculates the total potential area for coffee production in Kotido at 502,361 hectares, while only 6,054 hectares in Tororo. This is possibly due to the reality that Kotido is more than four times the size of Tororo. Besides differences in size, there exist stark differences in climate across the country. Some areas have two rainy seasons, while others have only one; the western region is characterized by a mountainous terrain while the central region boarders Lake Victoria. The existence of distinct climates results in distinct areas of crop production. High rainfall areas along Lake Victoria's shore are particularly good for banana and coffee production, and the low/medium rainfall in the north is associated with the growth of annual crops and the raising of cattle (Pender et al. 2004). Additionally, the GAEZ does factor in social or civil elements, specifically, the security issues in the North. Though fighting between the LRA and the Ugandan military has resulted in insecurity of property and person, the GAEZ is only concerned with calculating potential agricultural output with regards to soil, climate, terrain and inputs. Other elements that are excluded include transportation, specifically the ability of farmers to bring their produce to market, and limitations faced by farmers, with regards to inputs, credit, labor, and insurance. Consequently, the agricultural potential presented is limited, but nonetheless offers a glimpse of the agricultural potential of the districts in Uganda.

Figure 5: Coffee Potential at International and Local Prices Compared to Road Maintenance Grants (USD)

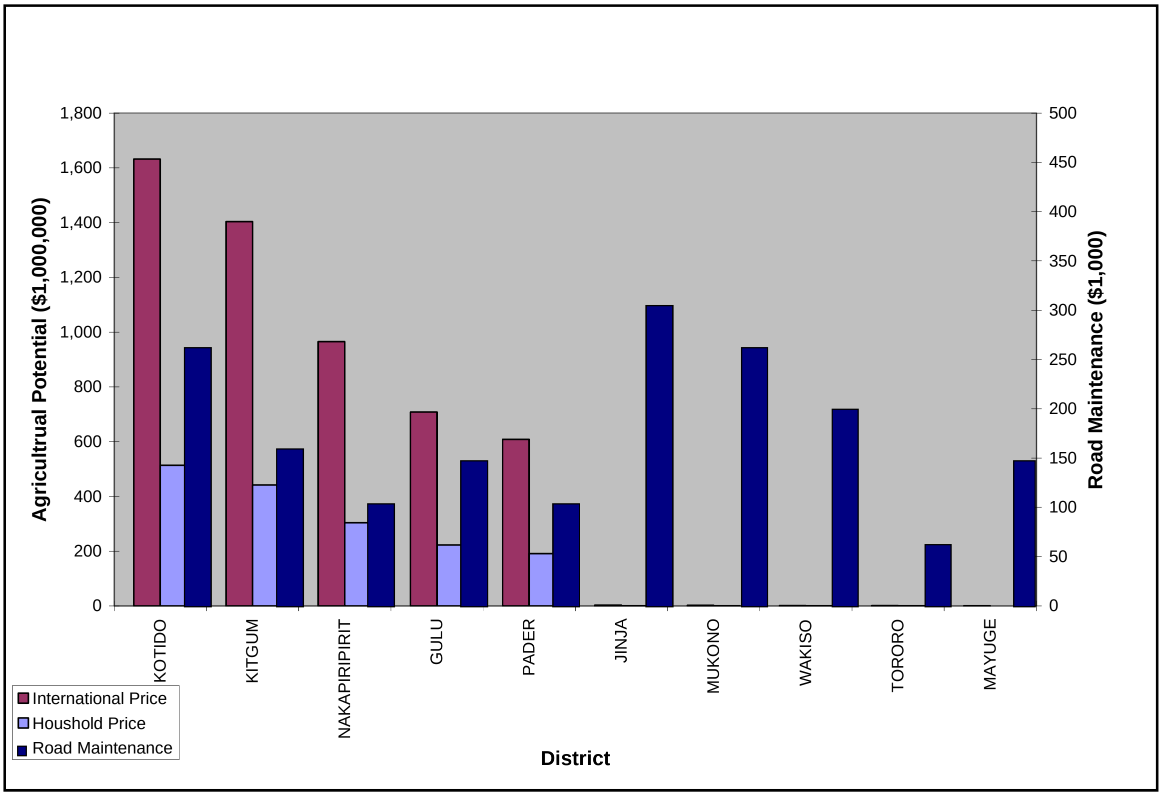
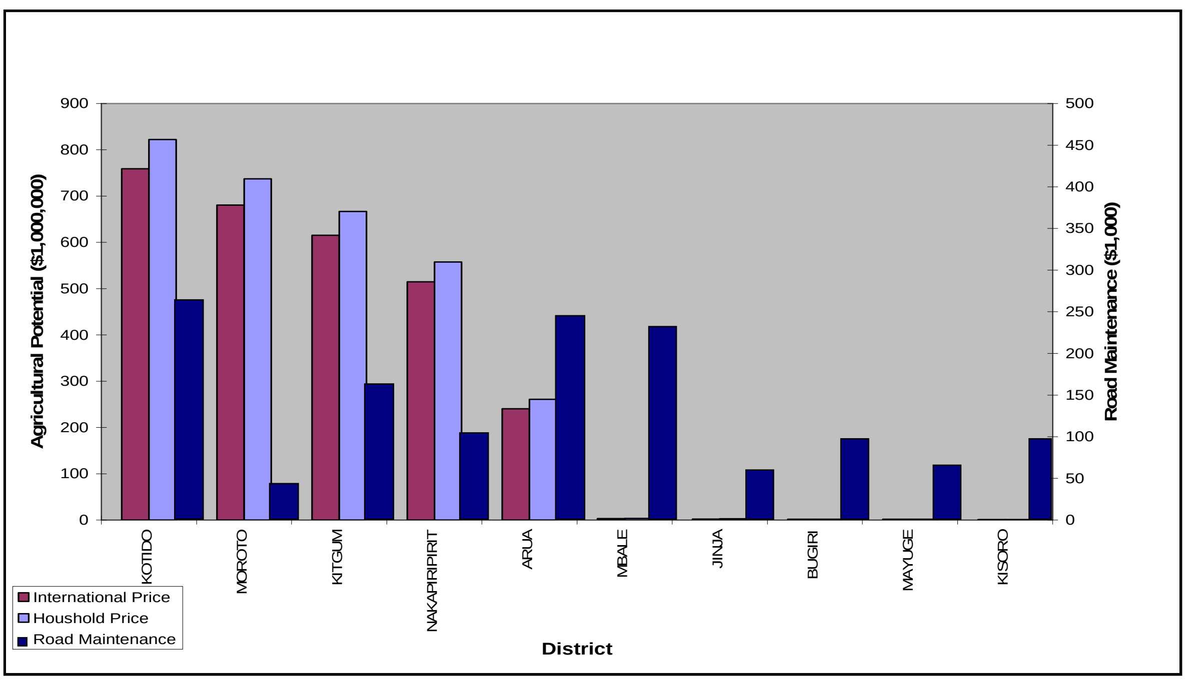


Figure 6: Maize Potential at International and Local Prices Compared to Road Maintenance Grants (USD)



This exercise demonstrates the lack of consideration of the agricultural potential in allocating maintenance funds for roads.

The sustainability issue of the current investment strategy

Based on the current size of the road network (in our selected districts), it seems that the present allocation only covers routine maintenance needs (for districts roads).[35] In the most favorable district, Tororo, periodic maintenance can ensured around 10 percent of the current network (on top of routine maintenance). In any case, in Bushenyi, the present allocation does not cover routine maintenance for the whole district network, which means that even without further expansion of the *district road* network,[36] its sustainability may be questionable.

Table 14: Share of Maintenance and Rehabilitation Needs (for districts roads) Covered by the Current Maintenance Allocation (in percentage)

	Bushenyi	Masindi	Tororo
Routine maintenance	88%	108%	138%
Routine maintenance + periodic maintenance (every six years)	29%	36%	46%
Rehabilitation	3%	4%	5%

Source: MOFPED for maintenance allocation per district; needs computed from road unit costs[37] and the size of the network.

Finally, the spending allocation for roads maintenance should be increased in order to make them sustainable. However, this mainly depends on the value added of the

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[35] Our selected districts are not among the lowest in terms of road maintenance allocation.
[36] We exclude community roads in our discussion, assuming that it is a second priority order.
[37] Following data were used for our computations:

	Road unit costs (in USD per km)
Routine maintenance	319
Routine maintenance + periodic maintenance (every three years)	1,278
Periodic maintenance	3,836
Rehabilitation	9,204
Low cost sealing	17,297

Source: Ministry of Public Works.

current production or the economic density of the selected districts. Table 14 demonstrates that if periodic maintenance is completely covered, between 8 and 19 percent of the district agricultural value added would be dedicated to roads maintenance and could then very rapidly reach an unsustainable point.

Table 15: Share of the Potential Spending on Periodic Maintenance Covered by Agricultural Sales (per sq. km)

	Periodic maintenance need (per sq.km) (in USD)	Share of the spending on periodic maintenance covered by agricultural sales (per sq.km) (in percentage)
Tororo		
District roads	357	**12%**
DR+ community roads	444	**15%**
Bushenyi		
District roads	241	**8%**
DR+ community roads	575	**19%**

Note: Agricultural sales are computed based on production of the three main traded products multiplied by median selling prices and divided by district area. Figures are the following: USD 3,049 per sq. km in Tororo and USD 3,014 for Bushenyi.

Therefore, full routine maintenance and partial periodic maintenance should probably be ensured. But anyhow, expansion of the current district network (in our selected districts) should be avoided otherwise questions of unsustainability of the funding of the network will soon raise a concern.

5. What could a more effective road allocation maintenance be?

The district roads maintenance fund in Uganda is allocated mainly by the length of the district road network in addition to a minimum standard amount for operational cost network (Ten year district, urban and community access roads investment plan, Ministry of Public Works and Transport, 2008). Therefore, the correlation between the actual and the "optimal" road maintenance fund allocation under different scenarios is calculated. The optimal allocation by district is a function of the agriculture potential, the population, the area, the length and the condition of the district road network[38] that depends on weights such as:

$$Optimal_i = \alpha * \left(\frac{Agr\ \ pot_i}{\sum_i Agr\ \ pot_i} \right) + \beta * \left(\frac{Pop_i}{\sum_i Pop_i} \right) + \delta * \left(\frac{Area_i}{\sum_i Area_i} \right) + \phi * \left(\frac{Length_i}{\sum_i Length_i} \right) + \eta * \left(\frac{Bad\ \ cond_i}{\sum_i Bad\ \ cond_i} \right)$$

where i represents each district.[39]

Table 16 presents the correlation coefficients between the actual district roads maintenance fund allocation and alternative allocation methodologies that take into account agriculture potential among other variables. When the function assigns more weight to the agriculture potential, the correlation between the two allocations is lower, which again demonstrates that agricultural potential is not a major variable for defining road allocation.

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[38] - **Actual district roads maintenance fund (2006).** Funds released by Ugandan government for district/feeder/secondary roads maintenance by district (vote 501-577, program 7). Data in Ugandan Shillings. 2006 data refers to FY 2006/07. Source: Draft estimates of revenue and expenditure FY 2006/2007, Ministry of Finance, Planning and Economic Development, 2007.

- **Agriculture potential.** Total potential cash crop area multiplied by the total potential production of the winner cash crop. Winner cash crop refers to the crop with higher potential yield (in Ugandan Shillings). Cash crop prices account for the price farmers sell direct to the market. Cash crops are coffee, maize, bananas, groundnuts and cotton. Sources: GAEZ (potential data) and household surveys (for cash crop prices).
- **Area.** Total area by district measured in kilometers squared. Source: UBOS.
- **Network length**. Number of kilometers of district/feeder/secondary roads by district. Source: Ten year district, urban and community access roads investment plan, Ministry of Public Works and Transport, 2008.

[39] During the last decade Uganda has been increasing the number of districts by dividing the original districts from 2002. Therefore, we aggregated the values of the divided districts to match the 2002 sample (56 districts).

Table 16: Correlation Between Rural Road Investment Strategies and Current District Road Allocation Maintenance

Parameters (weights)					Correlation between actual and optimal district roads maintenance fund
Agriculture potential (α)	Population (β)	Area (δ)	Network length (Φ)	Network in bad condition (η)	
0	0	0	1	0	**0.78**
0.2	0.2	0.2	0.2	0.2	0.65
0.5	0.125	0.125	0.125	0.125	0.35
0.75	0.0625	0.0625	0.0625	0.0625	0.20
1	0	0	0	0	**0.11**

Table 17 demonstrates that the agricultural potential varies tremendously between districts in Uganda. Districts in the North of the country such as Yumbe, Moroto, Kitgum seem to have a much higher potential than districts in the South-West, such as Kisoro or South-East, such as Bugiri. In terms of agricultural growth for Uganda, roads investment may be economically justifiable more easily in some districts in the North, such as Moroto or Kitgum and not necessarily in the South-West, such as Kisoro or Kabale (Table 18).

Table 17: Agricultural potential per sq. km per district (in USD)

Yumbe	4,393
Moroto	4,393
Nakapiripiriti	4,289
Kitgum	3,688
Adjumani	3,404
Mukono	89
Bugiri	80
Mayuge	77
Kisoro	74

Note: it is computed as the agricultural potential divided per the district area.

Table 18: Difference Between Total Agricultural Potential and Road Maintenance Needs (in USD)

Moroto	37,128,108
Kotido	36,724,816
Kitgum	34,927,546
Gulu	25,699,983
Nakapiripiriti	24,669,255
Bugiri	- 25,666
Kalangala	- 93,900
Ntungamo	- 110,066
Kisoro	- 264,947
Kabale	- 477,288

Note: it is computed as the difference agricultural potential and maintenance needs computed as the current network length multiplied by a unit cost of periodic maintenance per kilometer.

However, like demonstrated earlier, investment in infrastructure is economically justifiable as long as consolidated production enables reasonable agglomeration to enable transportation per truck. The next section presents some computations on the production threshold to make trucking services at a reasonable price.

6. How to foster load consolidation?

Like Smart (2008) demonstrates and what is relatively well known, "when origin–destination freight flows are large compared to the capacity of a standard vehicle, then the optimal routing is point-to-point because all standard vehicles are likely to achieve high load factors, and the point to-point routing minimizes travel distance. However, when the capacity of the most efficient vehicle is large compared to the average origin–destination freight flow, then consolidation and deconsolidation of freight at hubs becomes optimal. In such an optimal network, smaller, less efficient vehicles would be used to feed freight into hubs and distribute it from hubs to final destinations while large efficient vehicles would perform the interhub haulage". In most cases this is forgotten in rural transport.

In this section, minimal thresholds in order to create sustainable trucking transport are computed and models of consolidation that allow small farmers to remain independent, but capitalize on the power of consolidation are described. This consolidation can occur at different levels, among the farmers themselves, i.e. the producer groups in Poland, or at a higher level in the chain where the farmers output is consolidated at a single point by and outsider, i.e. the e-Choupal model or contract farmers/outgrower schemes.

Strong incentives not to consolidate

Coordination problems take root in game theory, whether or not authors explicitly note the ties to game theory, it is present. Game theory is applicable to agricultural economics because of its ability to model interactions between individuals, specifically the farmer/seller and the trader/buyer. The interaction of these two individuals is represented by a coordination game (also know as the 'prisoners' dilemma'), whose features include two choices for both individuals, with two equilibriums (Grabowski 1999). The presence of multiple equilibriums is where the problem exists; there is a high equilibrium and a low equilibrium. As presented in Table 19, both the buyer and the seller have two choices, Option I or Option II. These two options represent either investing (Option I) which gives a greater return or not investing (Option II) which results in a lower return. There are two equilibriums present in this figure, both choose Option I or both choose Option II. If both select Option I their return is five, but if the buyer cheats and selects Option II instead, the buyer receives eight and the seller receives nothing. To remove the risk of receiving nothing, the players will choose Option II, the low equilibrium, from which they will have little incentive to move from (Grabowski 1999).

Table 19: Farmer/Trader Dilemma

		Seller	
		Option I	Option II
Buyer	Option I	**5,5**	0,8
	Option II	8,0	**2,2**

Source: Grabowski, R. (1999).

The situation now becomes a low level equilibrium trap that is caused by a fear of coordination risk, the risk of investment failure due to the lack of complementary investment by the other player (Kydd and Dorward 2004 and Smart 2008). This risk deters farmers from investing more into their land and crops out of fear of not finding a buyer. For example, a farmer may improve his soil condition resulting in a better quality product, but the buyer/trader is not willing to pay more for this quality improvement. Examples of this fear are present are all over; producers often cite the lack of a buyer as a marketing problem (Kindness and Gordon 2001). Conversely, a trader may decide to invest in a better/larger mode of transport only to find out that the farmers he purchases from do not have enough produce to make his larger mode of transport economically viable. Kydd and Dorward (2004) identify the existence of a threshold level of investment which extends the entire supply chain. Below this threshold the players face no incentive to invest, but above the threshold returns from investment will continue to spur on growth and more investment. Unfortunately, the poor rural farmers have disproportionately higher rates of risk than other groups in developing countries, making the rise above the threshold difficult (Anderson 2003; Barrett 1996). Nonetheless, there are opportunities to break the coordination problem.

One option: selling directly to markets

For a small farmer with a plot size of one hectare, selling directly its product to the first local market by walking or by bicycle is the most economical option, which seriously limits the transport infrastructure requirement for the last mile for most villages. Some research suggests that IMT may provide a more direct connection for rural farmers. With rural areas difficult to access, the few traders that do come have little competition and are at an advantage in the transaction compared to the farmer (Porter 2002). Instead of incurring the financial burden of a motorized vehicle, IMTs can substitute when producers are traveling short distances with smaller loads (Porter 2007; Sieber 1999).

Nevertheless, IMTs are still just the connector, as consolidation must occur at some point for these rural farmers. This is especially the case when farmers are far from urban centers and do not have the time to bike or push a hand cart to the market. Instead IMTs could be used as a mode of transportation that moves produce to a collection point, where larger vehicles can consolidate into several small loads into one large load (Sieber 1999).

The usual option: market intermediaries

There are different approaches to overcoming the coordination trap that characterizes the current situation faced by small farmers. One approach is the use of market intermediaries to facilitate the transaction between buyer and seller. Market intermediaries become the link, and can take different forms, from the *ddebe boys* in Uganda to the *delala* grain brokers in Ethiopia to the sub-collectors and wholesalers in Madagascar.

Market intermediaries offer themselves as a possible solution, but can quickly turn into middlemen exploiting farmers for their own gain. The study conducted by Fafchamps and Hill (2008) in Uganda shows that increases in international prices of coffee are not followed by increases in local price. Instead, the price increase signals the entrance of another level of middle men, called *ddebe boys*, traders who travel from farm to farm purchasing coffee from farmers then selling to wholesalers. From *ddebe boys* on up prices rise with the international price; it is only the farmers who are left out, mainly because of their lack of knowledge of international demand and prices (Fafchamps and Hill 2008).

Sub-collectors in Madagascar serve as the bridge between farmers and wholesaler. Sub-collectors usually live in the village that they work, their purpose is to purchase crops from individual farmers and consolidate the crops into one load (Barrett 1997).

Other examples of intermediaries exist around SSA, and are typified by the high margins between the price that the traders purchase the crops from the farmers and the price that the traders sell the crop to the wholesaler or consumer. In Malawi the selling price is 149 percent higher than the purchase price (Fafchamps et al. 2005).

However, even though local storage is available and accessible, the farmers will face the same coordination problem to access to better prices and pay low transport cost filling a truck.

To which yield/farming size consolidation is a must?

Assuming that competition on the trucking industry requires at least five trucks on the same route, it is possible to compute what is the catchment area needed to make economically viable transportation by these trucks. At the current production level (of approximately 1 ton of cash crop per year per hectare), trucks would need to consolidate the production of at least 600 farmers), which would mean that truck could probably serve only one out of three villages in the production area, the non served villages would have to transport their production by IMTs to the served village. It is obvious that for 10 trucks equivalent, the number of non-served would increase tremendously.

Table 20: Catchment Area (in numbers of farms and villages) for the Equivalent of 5 and 10 Trucks Traffic

	Need for 5 trucks-equivalent Traffic (3 times a week)	Need for 10 trucks-equivalent traffic (3 times a week)
Case 1: 1 tonne per hectare		
Number of farmers	600	1200
Number of villages	**3.0**	**6.0**
Case 2: 5 tonnes per hectare		
Number of farmers	120	240
Number of villages	**0.6**	**1.2**

Note: computations are made for a 5 ton-truck transporting goods over 30 km, with return load, USD 4,000 of fixed costs and charging at USD 1.2 per kilometer.

This phenomenon is worth being noted because there is trade-off between individual traffic (for roads and trucks) and catchment area, usually neglected on the assumption that traffic will grow coupled with a smaller catchment area. In reality and in the short and medium term, increase in individual traffic (for a road) can only come at the expense of a larger catchment area, which explains why investments in large infrastructure and services in rural areas should be prioritized carefully and in any case, there should not be any objective to serve all settlements with roads designed for trucks.

How to break out of the coordination trap?

A. Producer groups

After the end of the communism rule in Poland in 1990, many farmers were lost without the direction and reliable purchasing by the government. In the free market economy many farmers suffered, especially because of their small land holding and their inability to compile with quality standards. In response, the Polish farmers organized producer groups. In producer groups all farmers retain control over their land and the group only exists to act as a market intermediary who coordinates sellers and buyers in the hopes of obtaining higher prices for their output (Banaszak 2007). The benefits from the group stemmed from diminished transaction costs to the sellers; instead the group manager searches, negotiates, communicates, contracts and monitors the transaction. By consolidating their output, the producer groups could now organize, pick up, and transport of their crops to buyers and utilize their size to negotiate for higher prices (Adamowicz and Lemanowicz 2006). The producer group acts as a point of consolidation of agricultural output, where the large size of the output is used as a marketing strength. In fact, on average group members received a premium of 6.2 percent on their products, with some groups reported premiums as high as 39 percent. Though all of the successful groups participated in joint sale, 57 percent of successful and 27 percent of partially successful groups participated in joint transportation. Therefore, the strength comes not only from the large quantity that can be sold, but also from the ability to take advantage of economies of scale and transport that large quantity of output in on large truck, without having to picking up small quantities from several farmers.

To pinpoint the elements of success, an ordinal probit model was run with the level of success as the dependent variable. The results included positive and significant coefficients on the preexistence of business relations between members, a selection process for members, and the leader’s strength and the number of members (Banaszak 2007). The lessons learned for the experience of producer groups in Poland is the need for groups to be developed by those directly involved in the production, farmers who already have business ties. The producer groups should also establish a selection process for members and seek to create legal recognition of the group. There is also the need to recruit more members in order to increase market share and bargaining power with purchasers.

B. Consolidation through ITC: the e-choupal model

The e-Choupal is the brain child of the Indian Tobacco Company (ITC)'s International Business Division. The idea came in response to the challenges of acquiring agriculture in Indian, problems that included small size/fragmented farms, multiple intermediaries, and poor infrastructure (Indian Planning Commission). To overcome these problems ITC developed the e-Choupal, which means village meeting place in Hindu, as a way to connect directly with the farmers using internet kiosk.

Before the e-Choupal, after harvesting their crop, farmers could either sell to a trader or bring their crops to mandis, regional markets established by the government. Once farmers have brought their crop to the mandi there was a period of visual inspection by potential buyers, followed by an open live auction (Bowonder et al. 2002). After the price has been established and bids won, the farmer brought their produce to the weigh areas that were operated by the buying agent. At the weigh areas the produce was bagged into sacks and weighed. With the full weight of his produce calculated, the farmer collected his cash payment.

Though simple in design, the mandi system has numerous inefficiencies and problems. Most importantly is that the farmers do not have information about pricing before hand, except what is heard in ones the local village. Therefore, farmers may not have been selling their crop at the optimal time which would have allowed them to maximize their income (Annamalai and Rao 2003). Other unsavory practices exploited the farmers, including the under-weighing of their produce, the obligation of the farmer to pay the costs of weighing and bagging, and the farmer not being paid the full amount at the time of sale, instead they had to come back to the mandi for the remaining amount owned to them (they were not paid interest on this delay of payment). In addition, the mandi system caused problems for the companies at the end of the line, such as ITC. The multiple handling stages resulted in increased time and costs, inconsistent quality of produce, and inflation of prices by the commission agents, both at the mandi and to the trading company (Annamalai and Rao 2003). With these issues in mind, ITC thought that dealing more directly with the farmers could eliminate a number of these problems. The e-Choupal was designed to facilitate this more direct connection.

The first step is identifying the location for the e-Choupal, the location acts as the hub with spokes reaching out to neighboring villages. On average 600 farmers from 10 villages within 5 km are served by one e-Choupal. Once the village is identified, a *sanchalak* is selected, he is also a farmer (Annamalai and Rao 2003). The *sanchalak* is the operator of the e-Choupal. The computer is placed inside the home of the *sanchalak* and this farmer acts as the intermediary between local farmers and the e-Choupal. The *sanchalak* is an important a vital piece that makes the e-Choupal successful who must be willing to accept the responsibility and have the entrepreneurial spirit to undertake the project. To insure their commitment the *sanchalak* must take a public oath to serve the farming community, because of this the position the garners respect and prestige within the village (Bowonder et al. 2002).[40]

Once installed, the *sanchalak* accesses information from the e-Choupal regarding weather, new and best farming practices, and market price information, which is gathered from mandis. With this information the farmers are now capable of making an informed decision; they can either sell their produce to ITC or at the mandis. The price offered by ITC is based on the mandi's closing price of the previous day, this price is the highest possible price, and it is reduced depending on produce quality. If a farmer chooses to sell to ITC he first brings a sample to the *sanchalak*, who conducts a quality assessment using a check list (this provides transparency in pricing). The *sanchalak* then gives the farmer a tentative price quote; from there the farmer proceeds to an ITC procurement hub with his produce. ITC's goal is to have a hub within 30 to 40 km of every farmer. At the hub another quality test is undertaken, with price deductions resulting from the presence of foreign matter or moisture content, concepts that are well understood by the farmers (lab tests are not yet accepted by farmers). After inspection the produce is weighed using an

[40] To install the computer in the sanchalak's home ITC spends between $3,000 and $6,000, and about $100 per year to maintain it (Annamalai and Rao 2003). The set up includes insuring constant power supply (ITC may install solar panels if needed), telecom connectivity, and bandwidth. Along with the technical aspects, ITC also trains the sanchalak to use the e-Choupal and there is a 24 hour helpdesk available. Though the sanchalak makes a commission on every transaction processed through the e-Choupal, there are costs to the sanchalak, including power and phone lines which can run between $60 and $160 per year.

electronic scale, removing possible human errors or other dishonest practices that may have occurred at the mandis. With the price and weight known, the farmer then collects his full payment at the hub payment counter. At that time, the farmer is also reimbursed for transporting the crop, and receives a copy of the lab report and a receipt.

The result of the e-Choupal system has been a win-win for farmers and ITC. With greater information and understanding of prices, farmers have become more aware of what they should/can receive for their crop. When farmers sell to ITC through the e-Choupal, prices are 2.5 percent higher on average then if sold at the mandis (Annamalai and Rao 2003). And even though ITC is paying more for the produce and compensating farmers for transport, ITC is paying less than before (Prahalad and Hammond 2002). Because ITC cut out the intermediaries the mark up paid by ITC has decreased from 5 to 2.5 percent. ITC is not finished there, currently, there are 6,500 e-Choupals serving four million farmers; the plan is for a total of 20,000 e-Choupals serving 10 million farmers in the next five year (ITC website[41]). In addition, ITC is starting to expand operations in the reverse direction, bring goods to rural areas, through structures called Choupal Saagars.

C. Contract farmer/outgrower scheme

Contract farming or outgrower schemes are methods that firms employ to utilize the existing assets of small rural farmers. "Contract farming is a vertical coordination between a central processing or exporting unit on the one hand, and growers of agricultural products" (Al-Hassan et al. 2006). The coordination is based on a contract that outlines the purchase of the crop being grown, beforehand. In general, inputs (seeds, fertilizer, pesticides) and extension services are provided by the firm to the farm free or at a lower cost to the farmer, who in turn grows the crop and sells it to the firm at the previously agreed upon price (Kindness and Gordon 2001). Specific elements of the contract can vary, such as the extent of control over the farmer by the firm or if a certain amount of output was agreed upon, etc. There is great potential for both good and bad to come of this contract. A study of small Zimbabwean farmers asked what the motivation was for entering a contract; the top responses were market uncertainty, indirect benefits (i.e. knowledge), increased/secure income and intangible benefits (Masakure and Henson

[41] ITC website: www.itcportal.com/rural-development/echoupal.htm (accessed March 19, 2009)

2005). As a result, even if the farming contract does not continue, farmers have gained greater knowledge about growing techniques, inputs, and the market. However, in any situation where there is a large firm interacting with small holders, problems can occur that are related to the farmers' motivation for entering the contract.

The problem with contract farming is the power relationship that develops between the farmer and the firm, with the firm exploiting the farmer. These contracts also exclude certain groups from the schemes, which places them at a greater disadvantage, including the landless poor, women whose labor is exploited by their men, and children whose free labor is utilized by their parents (Porter and Phillips-Howard 1997). In addition, by not directly employing the farmers, firms are able to stay in control of crop production without incurring the costs of full time employees. As time progresses, farmers may become more invested in growing the specified crop for the firm, this can result in limited alternatives and no exit strategy leaving the farmer at the firm's mercy (Key and Runsten 1999; Porter and Phillips-Howard 1997). There are additional concerns about food security in areas that are highly invested in producing a cash crop for the contracting firm; a possible side effect may be less growing of food staples. Thus, local food prices being to rise as food shortages strike local communities (Warning and Key 2002; Key and Runsten 1999; Porter and Phillips-Howard 1997).

7. Policy recommendations on the approach on roads investment strategy in Uganda

The WDR 2009 recommends that in lagging areas countries should invest in people, while in leading areas they should invest in place. This combination provides people in lagging areas with education in enhancing their opportunities, while the improved infrastructure will allow mobility of people, (agricultural) goods and information to and from the leading area.

This statement is qualified with numbers and concludes that the average farmer does not necessarily require massive investments in rural infrastructure from primary markets to the village, homestead or farm gate because they can neither afford to hire a truck nor load it sufficiently to break even if they could. Even if their agricultural productivity was *significantly* higher, most smallholder farmers could not approach the production threshold they would need to reach to justify hiring a truck.

Therefore, the conclusions are the following:

(i) Rural transport policy and investments in Uganda should give more attention to the intermediate means of transport which allow farmers to take their crops from the farm gate to sell their production in local markets;

(ii) Subsequently, maintenance of existing rural roads rather than new roads should be given priority in most cases;

(iii) Policy makers should give attention to innovative marketing models from other countries such as India where smallholder loads are consolidated through consolidators;

(iv) An alternative objective and strategy is proposed, which would take into account much more strongly agricultural potential. We propose a two-pronged approach: first define the road allocation per district as a direct function of agricultural potential, contemplating the economic benefits of areas with strong agricultural potential, and second, minimal road connectivity would be defined per region such as connectivity at less than 8 or 10 km for Ugandan rural population; and

(v) When implementing this methodology, it appears that roads rehabilitation could be done in some districts in the North and roads allocation should be reduced for some districts in the South West.

Like Qadeer (2000) demonstrated, local agglomeration, what he called "ruralopolis" high-density rural settlement systems based upon examples and observations from south Asian ruralopolitan regions, should be sought.

And the 'missing middle' has often been ignored in prioritising road investments and should be given attention instead of rural roads as such. Main roads tend take priority for governments, while Community Driven Development (CDD), i.e. agriculture and social groups operating within donor agencies, have been more interested in supporting the feeder road network. As a result secondary roads can often be observed to be in a far worse physical state than the feeder roads that connect to them. This is despite the fact that secondary roads may take a hundred times the traffic of the connecting feeder roads.

There are indications in the literature that a "one size fits all approach" is not effective in addressing the problems of African countries. "In some countries large sums of money have been wasted in building roads to high geometric standards with excessive carriageway widths for these low volumes of traffic (Ellis and Hine, 1998)." Instead, countries need to adopt an approach that supplies the appropriate road for a rural area. A large road may not be required in most cases in Uganda.

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Annex 1: Overview of the selected districts in Uganda

Bushenyi district is located in the south western Uganda, with total area of 3.949 sq. km, at higher altitude than most districts in Uganda. Bushenyi district has a total census population of 738,355 (2002) and projected population of 823,101 (2008) with an average density of 187 persons/sq. km and 208 persons/sq. km respectively.
Vegetation: The vegetation consists of tropical forest, woodland, grassland and farmland consisting of perennial crops which include bananas, coffee and tea.
Climate:

- Rainfall: Average of 1200 mm rainfall is received, but has ranges of 1000mm, 2000mm
- Temperature: 22° C
- Maximum temperature range: 22.5° to 30° C
- Minimum temperature range: 10° to 20° C

Seasons: Bushenyi experiences four seasons:

- January – February Short dry spell
- March - June Wet season
- June - August Long dry season
- September – December Long wet season

Masindi district is located in the mid-western part of Uganda, with its headquarters 216 km away from Kampala, covers an area of 7,216 sq. km of which, 195.6 sq. km is palm wet land and 7,020.4 sq. km is arable land. The district current (2007) population is estimated to be 512,700.
Major economic activities are carried out in medium and high rainfall zones and include maize, cassava, tobacco and banana growing. This has contributed to increased household incomes enabling the population to sustain their livelihoods. The natural vegetation of Masindi comprises of forest, dry and humid savannahs.
Climate: Masindi has a favorable climate, and its rainfall pattern is bimodal. The district receives an annual long-term average rainfall of 1,304mm.

Tororo district is located in eastern Uganda. The district has a total area of 1,211 sq. km. The district headquarters is located in Tororo municipality, which is 214 km from Kampala city. Tororo town is 1,459.5 meters above sea level. The district has a total population of 445,115 of which 92.6 percent of the population lives in the rural areas whereas only 7.3 percent of the population live in the urban areas.
Climate: Tororo district has a sub-humid climate with orographic and bi-modal rainfall with peaks during the months of May and October.

- Rainfall: Average of 1130 mm to1720 mm
- Maximum temperature range: 16.2°C to 28.7°C

Relative humidity ranges between 52 to 89 percent.

Annex 2: Definitions for the UNSHS surveys

Expenditure on Foods, Beverages and Tobacco during Last Seven Days

This part determines the household's total expenditures on food purchased at the market place, and to estimate the value of home produced or home-grown food items consumed by the household as well as food received as gifts, presents from relatives and/or friends, or as payment in-kind i.e. remuneration for work done on someone else's farm.

Items consumed at home and away from home during the past seven days. Home production refers to items produced or grown by the household which have been consumed by the household during the past seven days. The quantity and value of items that the household received in-kind as a gift, presents from relatives and/or friends or as payment in-kind and consumed during the past seven days

All three categories were summed to create a measure of total household consumption.

Tarmac Roads

Trunk roads are main roads maintained by the central government and they are normally connecting a district to the other, they are six meters and above in width.

All Season Feeder Roads

All Season Feeder roads are major roads joining trunk roads that are accessible year round and are maintained by district authorities (local governments).

Agricultural Income

The sum of the value of the total sales of each crop for one household, the measure is for one farming season and is in Ugandan Shillings.

Limited Consumer Market/Outlet

A limited consumer market or outlet will be either a cluster of shops and traders (market) or one or a few scattered shops where generally only a limited number of fast selling commodities and services but with limited choice.

Agricultural Input Markets

A general agricultural input market selling limited inputs refers to markets that sell a variety of goods and services including farm inputs. These are not specialized farm-input markets and sell such goods to a limited extent only.

Agricultural Producer Market

A general agricultural producer market selling a variety of goods relates to markets/ traders where agricultural produce are sold or bought in bulk or/and small quantities. These are not specialized farmers markets-they sell such goods to a limited extent only.

Most Common Agricultural Input/Producers Market

The most common agricultural input/producers market that sells inputs/outputs (crops).It is a specialized market where most of the needed farm-inputs and outputs are available for sale.

Other Transportation

Unsure of what this entails, it was not defined in the Survey Manual.

LC1

The community questionnaire was administered at Local Council 1 (LC1) level in the selected enumeration areas (EAs). The Local Council (LC) system is a decentralized, hierarchy of councils and committees that govern their assigned area. There are three levels of LC (1, 2, & 3), with 1 being the smallest level of aggregation.

Annex 3: Assumptions regarding the cleaning of the GPS data from the household surveys

Based on the numbers in the dataset, it was assumed a geographic projection (WGS 1984). It was assumed that the numbers were recorded in decimal degrees (given the format and variance in numbers - the numbers ranged from two to nine digits for any given coordinate. It were converted the numbers to decimals because they did not have decimals prior, so it was assumed that each y (latitude) was divided by 100,000 in order to allow the numbers to fall between one to four degrees latitude (Uganda's lat.); the x (longitude) was divided by a series of numbers depending on the digit length of the observation. Since excel usually loses leading zeros this throws longitude data on the other side of the globe. The dataset also has some coordinates in a UTM projection instead of the geographic projection that it was assumed. About 274 points are in this projection. It was projected these points and found that some of them had reversed latitude and longitude's recorded. It was assumed this, and corrected the points. It was also assumed the data for the UTM projected points: which was WGS 1984, with UTM 36N. Those households that are surveyed to be in Mbara but whose GPS coordinates placed them at least 22-23 km north of Equator and in a different district (notably Kibale, Kammenge, Kabarole, Kyenjojo) are assumed to be south of the equator and therefore have been corrected with a negative latitude. Those households that are surveyed to be in Sembabule but whose GPS coordinates placed them at least 22-23 km north of Equator and in a different district (notably Mubenede, Mpigi) are assumed to be South of the equator and therefore have been corrected with a negative latitude.

Source: Emily Schmidt.

Annex 4: Mean of consumption of each quintile of distance compared to distance to the nearest city

Figure 1: Mean of consumption of each quintile of distance compared to distance to the nearest city

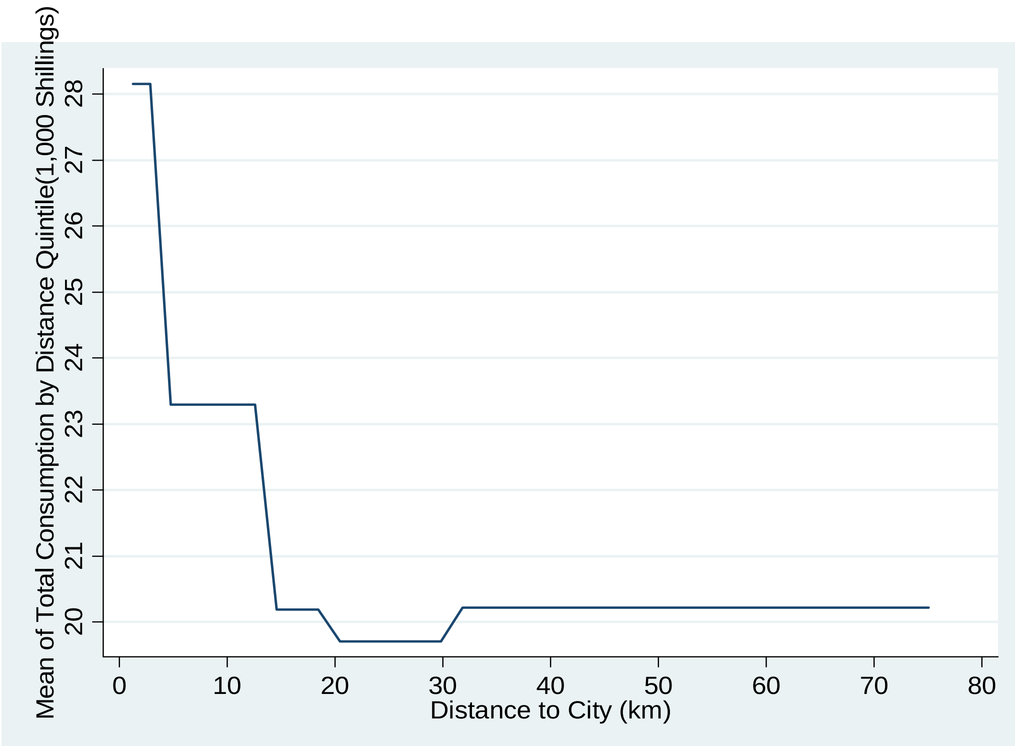


Table 1: Range of the distance quintiles and the mean consumption of the quintiles

Quintile of distance	Range of distance by quintile (km)	Mean of total consumption by quintile
1	0.115 to 4.509	28.152
2	4.512 to 12.903	23.293
3	12.904 to 19.898	20.186
4	19.899 to 30.883	19.707
5	30.902 to 75.103	20.214

Annex 5: Definitions, calculations & rationale for the three districts household surveys

Income: Income is the revenue generated from crop sales minus the cost of growing those crops.
Income = Revenue – Cost

Revenue: The summation of the weight of all the crops (i) sold multiplied by their selling weight for each household (j).
$\text{Revenue}_{ij} = \sum(\text{Weight Sold}_{ij} * \text{Selling Price}_{ij})$

Costs: The summation of all costs, input, transport and labor.
$\text{Total Cost}_{j} = \text{Input Cost} + \text{Transport Cost} + \text{Labor Cost}$

Input cost: For fertilizer, pesticides, and seeds the cost was equal to the weight purchased multiplied by the selling price of input (k).
$\text{Input Cost}_{kj} = \sum(\text{Weight Sold}_{kj} * \text{Selling Price}_{kj})$

Transport cost: Cost of transporting crops to the market for sale (if applicable) for the household (j).
$\text{Transport Cost}_{j} = \sum(\text{Transport Cost to the Market})$

Household Size: The total number of people residing in the household as reported in the survey. Calculation:
(Male Children + Female Children + M. Adults + F. Adults + M. Elders + F. Elders)

- **Children**: Less than 16 years old.
- **Adults**: Between 16 and 45 years old.
- **Elders**: More than 45 years old.

Head Gender: The gender of the head of the household 0 is female, 1 is male.

Secondary: The total number of household members with secondary school education.
Other options for education were available including the total number of household members with secondary education and a total education variable that was the summation of the primary and secondary variables. However, there were strong correlations that existed between variables: household size and all education (.9), household size and primary education (.85), and all education and primary (.9). Therefore, secondary education was solely selected to represent the household educational status. The correlation between household size and secondary education was much weaker than between the other variables (.28).

Crop Type: A weighted average, by district, that represents the level of market participation by the households.
To calculate the weight, first we calculated the revenue generated by crop (i) for each household (j) in district (p).
$\text{Revenue}_{ijp} = (\text{Weight Sold}_{ijp} * \text{Selling Price}_{ijp})$

The revenue from each crop (i) is then summed to create the total agricultural revenue of the household (j) in district (p).
Total Revenue $_{jp}$ = $\sum$(Weight Sold $_{ijp}$ * Selling Price $_{ijp}$)

The total revenue of each household is summed to calculate the total return in each district (p).
Total Return $_{p}$ = $\sum$(Total Revenue $_{j}$)

The revenue produced by each household selling a specific crop is summed to give the total return earned per crop (i) in that district (p).
Total Return $_{ip}$ = $\sum$(Total Revenue $_{ijp}$)

The weight of each crop is equal to the total revenue of the crop (i) in that district (p) divided by the total return to the district (p).
Weight $_{i}$ = (Total Return $_{ip}$) / (Total Return $_{p}$)

These different weights are then applied to the corresponding crop while taking an average of the percentage of crops that are sold to the market. The result is greater weight given to those crops that have a larger percentage of the total harvested sold to markets. Therefore, a cash crop will have a greater weight than a subsistence crop.

For example, a household grows cassava and maize.
The household grows 100kg of cassava and sells 40kg (40%sold) and the household grows 50kg maize and sells 40kg (80% sold).
If we were it take an average of the percentage of crops sold:
[(40+40)/(100+50)]= [80/150]=.533 ≈
The household sells about 50% of its crops to the markets, however, this does not accurately represent the truth.
But is we were to calculate the weights, and say for example the weight of cassava is .2 and the weight of maize is .8 (a cash crop) the average percentage of crop grown would be [(.2*40+.8*40)/(.2*100+.8*50)]= .66
Resulting in a better representation of the household's involvement in the market through cash crops.

Own Bikes: The number of bicycles owned by the household. Note that motorcycles are not included, only 8.5% of the households surveyed own a motorcycle, and all but one own both a motorcycle and a bicycle.

Passability: The number of days per year that the household cannot use the road/path to the center of their village by bicycle. Bicycle was chosen because of the prevalence of its ownership. Only 9.6% of the sample does not own a bicycle. For those without this information, the average number of days for that district was substituted.

Yield: The yield represents the overall yield of the households' land by crop with each crop weighted. The weights are calculated district wide, it is the summation of the total area a crop (i) covers in a district (p) divided by the total amount of land in the district

(p). Greater weights go to those crops that cover more of the total land of the district. $\text{Weight}_p = \sum \text{Land}_i / \sum \text{Total Land}_p$
The weight of that crop (i) in that district (p) is then used when calculating the yield of the household, which is defined as the output of a crop per unit of land dedicated to that crop.
$\text{Yield} = (\text{Weight}_p * \text{Weight Harvested}_i) / \text{Land}_i$

Sell Direct: This variable is the fraction of the total weight of all crops harvested that is sold directly at the market by the household, not through a trader.
Sell Direct: $\text{Weight Sold to Market}_j / \text{Weight Harvested}_j$

Road Density: The amount of district roads (kilometers) in a district over the area of the district (kilometers squared). Sources: Ministry of Works & Transport and Ministry of Tourism, Trade & Industry.
Road Density = District Roads (km)/ Area of the District (km^2)

Tororo: A binary variable that is one when the household is in the Tororo District and zero other wise. Tororo is chosen because of it differences from Masindi and Bushenyi, smaller size, its location in the east, and bordering Kenya.

Note:
Five observations were dropped as outliers, comprising less than 3% of the observations. Three were dropped as *income* outliers, with values greater than 80,000 Shillings. The remaining two were dropped as outliers of the *yield* variable, with values over 2,000 kilograms.

Annex 6: Descriptive statistics on modes of transport in Uganda

Table 1: Bicycle (Masindi district)

	mean	median	st dev	obs
Price of the last bicycle purchased (USD)	48	45	13	41
Average load per bicycle per one way trip (kgs)	70	60	28	41
Number of trips per bicycle per month (times per month)	55	30	60	41
Average distance per one way trip (kms)	4	2	4	40
Average time per one way trip (hrs)	0.94	0.66	1.02	41
Fixed costs PER YEAR	mean	median	st dev	obs
Amount financed to buy the bicycle (USD)	-	-	-	0
Amount paid for interest (USD)	-	-	-	0
Age of the last bought bicycle (years)	7	6	4	33
Year purchased	2,002	2,002	4	33
Lifetime per bicycle* (years)	12	10	7	23
Others (specify) (USD)	-	-	-	0
Variable costs PER YEAR	mean	median	st dev	obs
New wheels (if bought) (USD)	11	8	8	23
Punctures (if repaired) (USD)	9	5	11	29
Repairs (wheels/bicycle) (if repaired) (USD)	17	10	16	31
Others (specify) (USD)	-	-	-	5

Source: surveys.

Table 2: Motorcycle (Tororo district)

	mean	median	st dev	obs
Price of the last motorbike purchased (USD)	1,113	1,132	496	8
Average load per motorbike per one way trip (kgs)	76	80	25	7
Number of trips per motorbike per month (times per month)	29	30	10	7
Average distance per one way trip (kms)	26	18	23	6
Average time per one way trip (hrs)	1.5	1.50	1.0	7.0
Fixed costs PER YEAR	mean	median	st dev	obs

License and registration paid per year (USD)	1	1	-	1
Insurance paid per year (USD)	6	5	1	3
Amount financed to buy the motorbikee (USD)	1,032	1,032	261	4
Amount paid for interest (USD)	-	-	-	0
Age of the last bought bicycle (years)	4	3	2	6
Year purchased	2,005	2,006	2	7
Lifetime per bicycle* (years)	8	9	2	6
Others (specify) (USD)	-	-	-	0
Variable costs PER YEAR	mean	median	st dev	obs
Fuel per year (USD)	101	8	190	4
Oil per year (USD)	18	18	18	2
New wheels (if bought) (USD)	68	68	-	1
Punctures (if repaired) (USD)	3	3	2	2
Repairs (wheels/motorbike) (if repaired) (USD)	38	38	18	2
Others (specify) (USD)	-	-	-	0

Source: surveys.

Annex 7: Variables definition and sources

- Released funds for feeder roads maintenance in 2006 (per capita). Funds released by Ugandan government for district/feeder/secondary roads maintenance (vote 501-577, program 7). Data in Ugandan Shillings. 2006 data refers to FY 2006/07. Source: Draft estimates of revenue and expenditure FY 2006/2007, Ministry of Finance, Planning and Economic Development, 2007.

- None major constraints. Percentage of district/feeder/secondary roads by district that do not face major constraints when being used. Source: Gender disaggregated data for roads sector based on the national service delivery survey 2004, Ministry of Finance, Planning and Economic Development, 2008.

- Network length per capita. Number of kilometers of district/feeder/secondary roads by district. Source: Ten year district, urban and community access roads investment plan, Ministry of Public Works and Transport, 2008.

- Number of constituents per capita. Number of representatives in the Parliament by district. Source: http://www.parliament.go.ug/index.php?option=com_wrapper&Itemid=37.

- Number of NRM constituents per capita. Number of representatives in the Parliament from the National Resistance Movement (official party) by district Source: http://www.parliament.go.ug/index.php?option=com_wrapper&Itemid=37.

- Area. Measured in kilometers squared. Source: UBOS.

- Poverty rate. Poverty rate by district for 2005/6. Source: World Bank.

- Rural consumption per capita. Rural consumption per capita by district 2002. Source: World Bank.

Annex 8: Agro-ecological zones methodology
(based on material from IIASA and FAO)

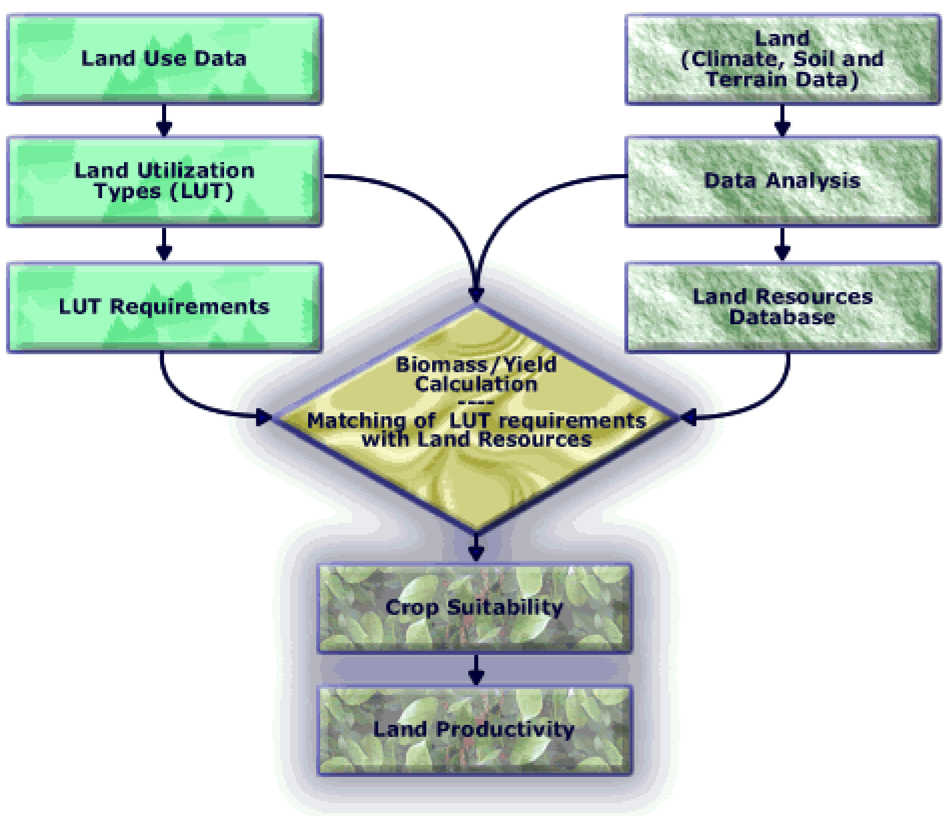
The AEZ framework contains three basic elements as sketched in the figure below:

(i) Selected agricultural production systems with defined input and management relationships, and crop-specific environmental requirements and adaptability characteristics. These are termed Land Utilization Types (LUT);

(ii) Geo-referenced climate, soil and terrain data which are combined into a land resources database, and

(iii) Procedures for the calculation of potential yields and for matching crop/LUT environmental requirements with the respective environmental characteristics captured in the land resources database, by land unit and grid-cell.

Conceptual framework of agro-ecological zones methodology



FAO and IIASA subdivide the AEZ methodology as follows:

First, AEZ provides a standardized framework for the characterization of climate, soil and terrain conditions relevant to agricultural production.

Second, AEZ matching procedures are used to identify crop-specific limitations of prevailing climate, soil and terrain resources, under assumed levels of inputs and management conditions. This part of the AEZ methodology provides maximum potential and agronomically attainable crop yields of basic land resources units (grid-cells).

Third, AEZ provides the frame for various applications, such as quantification of land productivity, extents of land with rain-fed or irrigated cultivation potential, estimation of the land's population supporting capacity, and multi-criteria optimization of land resources use and development.

Limitations of the Global AEZ study

While representing the most recent global data compilations, the quality and reliability of data sets is known to be uneven across regions. Especially the quality of the world soil map is reason for concern. It is based on a 1:5,000,000 scale map and it is generally accepted that its reliability may vary considerably between different areas.
Another issue is that the current status of land degradation cannot be inferred from the FAO Soil Map of the World.

Also the agronomic data, such as the data on environmental requirements for some crops, contain generalizations necessary for global applications. In particular assumptions on occurrence and severity of some agro-climate related constraints to crop production would, no doubt, benefit from additional verification and data.
Socioeconomic needs of rapidly increasing and wealthier populations are the main driving force in the allocation of land resources to various kinds of uses, with food production as the primary land use. For rational planning of sustainable agricultural development socioeconomic considerations are indeed crucial. So far, in Global AEZ the use of socioeconomic information is limited to the definition of modes of production and the quantification of 'input-output packages'. They are referred to as the land utilization types, taking, to some extent, into account the socioeconomic context of production decisions and conditions.

For the above reasons, the results obtained from this Global AEZ study should be treated in a conservative manner at appropriate aggregation levels, which are commensurate with the resolution of basic data and the scale of the study.

While various modes have been pursued for 'ground-truthing' and verifying results of the Global AEZ suitability analysis, there is a need for further validation of results and underlying databases.

Source: FAO.

Annex 9: Methodology to calculate agricultural potential

To calculate the agricultural potential of the districts in Uganda, data collected by the Food and Agricultural Organization and the International Institute for Applied Systems Analysis, called the Global Agro-Ecological Zones (GAEZ), was used. GAEZ utilizes information on climate, soil, terrain, and assumptions about inputs to construct a model of the agricultural potential of an area for 20 different crop types. The two outputs produced by the GAEZ are the potential area and the potential yield. The potential area, in hectares, is the amount of land that can be devoted to growing the crop, and the potential yield is the output, in kilograms, per hectare. To calculate the total potential output of each crop in each district, the sum of the potential area in a district was multiplied by the average potential output of each hectare in the district.[42] The resulting figure is the potential output of that crop for that district, which now allows comparison of agricultural potential across districts.[43]

Though the GAEZ is calculated for 20 crops, not all of these crops are widely grown in Uganda. The literature has shown that involvement in export corps decreases the likelihood of Ugandan households being poor (Balat et al. 2008), therefore, three of the four crops analyzed here were chosen because of their significance as exports. The fourth crop, maize, was chosen for its status as a staple in Ugandan diet. Referencing the Uganda Export Promotion Board, three crops were selected that appear both on the GAEZ list and on the Uganda Exports list, coffee cotton, and soy beans, along with maize. Coffee and cotton are considered traditional exports, with export volumes of 164,540 and 16,230 tones respectively in 2007; maize and soy beans are classified as non-traditional exports, with 101,233 and 5,798 tons, respectively, being exported in 2007 (Uganda Export Promotion Board).

[42] The crops are assumed to be exclusive, such that only one crop can be grown at a time.

[43] Assumptions and generalizations were made when calculating the GAEZs, for example, the outputs used in this report assumes a high rainfall. The GAEZ is presented as an approximation, limitations and shortcomings are outlined on the website http://www.iiasa.ac.at/Research/LUC/GAEZ/index.htm.

Annex 10: Transport prices in the selected districts

	Transport prices							
	Total		Masindi		Bushenyi		Tororo	
	(in cents USD per km)	(in cents US per ton km)	(in cents USD per km)	(in cents US per ton km)	(in cents USD per km)	(in cents US per ton km)	(in cents USD per km)	(in cents US per ton km)
Bicycle	47.9	811.7	57.8	978.4	..	..	15.1	256.0
Motorcycle	27.7	255.8	..	..	..	..	27.7	255.8
Pick-up	241.0	241.0	316.1	316.1	189.8	189.8	112.9	112.9
Lorry	455.4	75.9	548.6	91.4	473.4	78.9	247.8	41.3

Annex 11: The ten-year district, urban and community access roads expenditure

Category	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	Total
District roads	75.1	84.6	94.0	105.7	103.6	101.6	99.7	99.7	96.2	94.6	952.9
Community access roads	8	8	8	8	8	8	8	8	8	8	80
Sub-total	*83.1*	*92.6*	*92.0*	*112.7*	*111.6*	*109.6*	*107.7*	*107.7*	*104.2*	*902.6*	*1032.9*
Urban roads	14.3	20.5	26.8	32.6	32.7	32.7	32.3	32.3	32.4	32.1	288.7
Kampala city roads	22.5	25.2	25.2	25.0	24.8	24.5	24.3	24.1	23.8	23.8	246.1
Bridge works	2	2	2	2	2	2	2	2	2	2	20.0
Capacity building	0.9	0.9	0.9	0.9	0.6	0.6	0.4	0.4	0.4	0.4	6.4
Total	**125.5**	**141.2**	**156.9**	**174.2**	**171.7**	**169.4**	**166.7**	**164.7**	**162.8**	**160.9**	**1,594.2**

Note: Exchange rate: USD 1 = Shillings 1,850

Annex 12: Investment needs per types of work and per district

Table 1: Investment Needs for Various Technical Options for Tororo and Bushenyi (per sq. km)

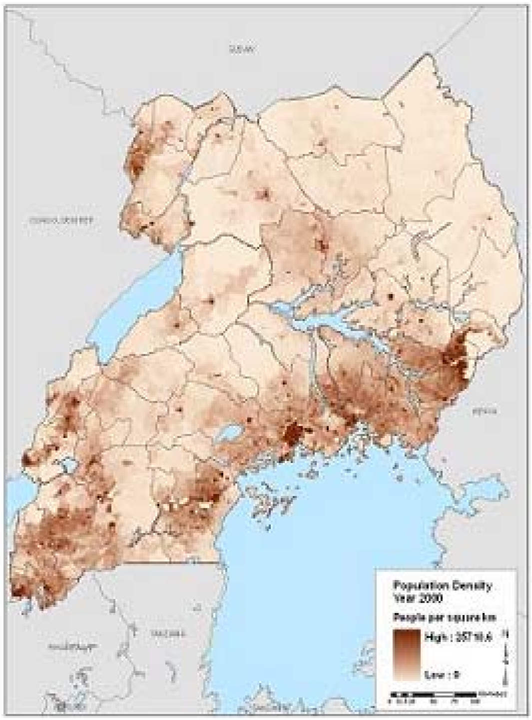
	Road density (in kms per sq.km)	Routine maintenance (in USD)	Routine + periodic maintenance (in USD)	Low-cost sealing (in USD)
Tororo				
District roads	***0.37***	119	476	6,442
DR+ community roads	***0.46***	148	592	8,013
Bushenyi				
District roads	***0.25***	80	321	4,345
DR+ community roads	***0.60***	191	766	10,374

Table 2: Investment Needs per Types of Work and per District

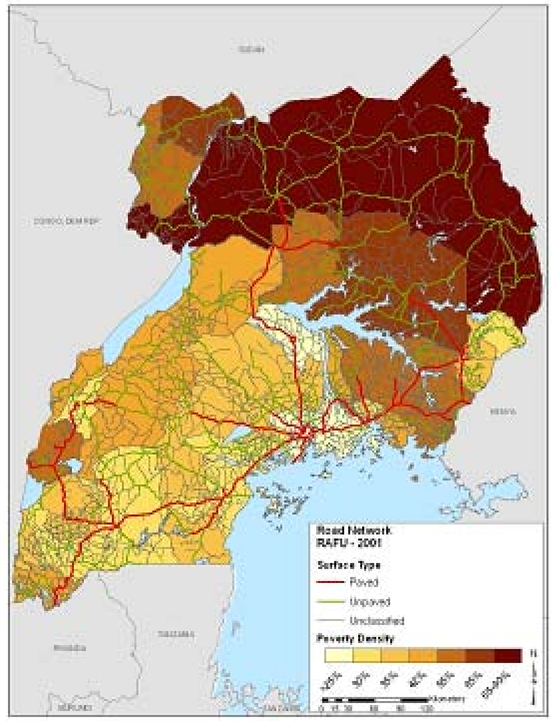
DISTRICT ROADS			
	Bushenyi	**Masindi**	**Tororo**
Routine maintenance	316,368	283,519	143,832
Routine and periodic maintenance	1,267,749	1,136,118	576,366
Rehabilitation	9,130,690	8,182,644	4,151,150
Low cost sealing	17,158,919	15,377,297	7,801,081
COMMUNITY ROADS			
	Bushenyi	**Masindi**	**Tororo**
Routine maintenance	438,992	637,838	35,081
Routine and periodic maintenance	5,280,552	7,672,432	421,984
Rehabilitation	12,669,752	18,408,649	1,012,476
Low cost sealing	23,809,730	34,594,595	1,902,703
TOTAL			
	Bushenyi	**Masindi**	**Tororo**
Routine maintenance	755,359	921,357	178,914
Routine and periodic maintenance	6,548,301	8,808,550	998,350
Rehabilitation	21,800,442	26,591,293	5,163,626
Low cost sealing	40,968,649	49,971,892	9,703,784

Annex 13: Maps of Uganda

(a) Population density

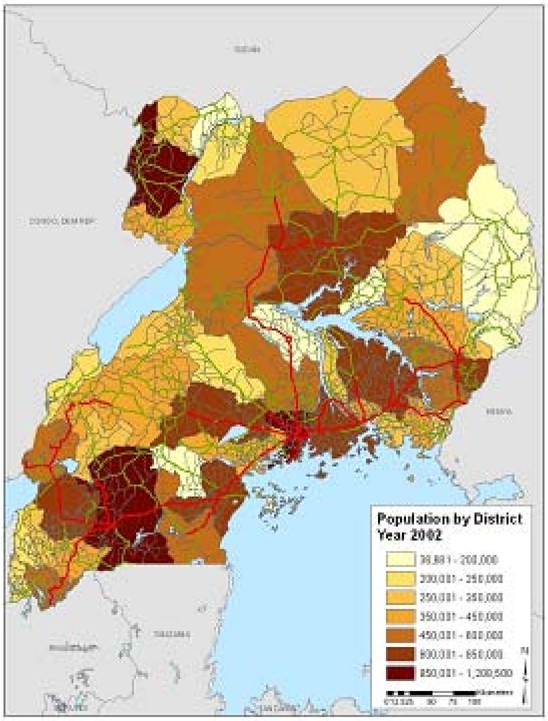


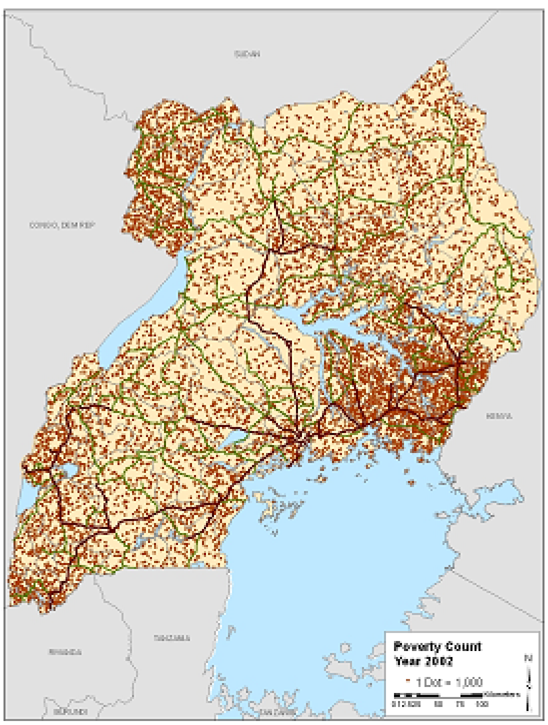
(b) Population density by district



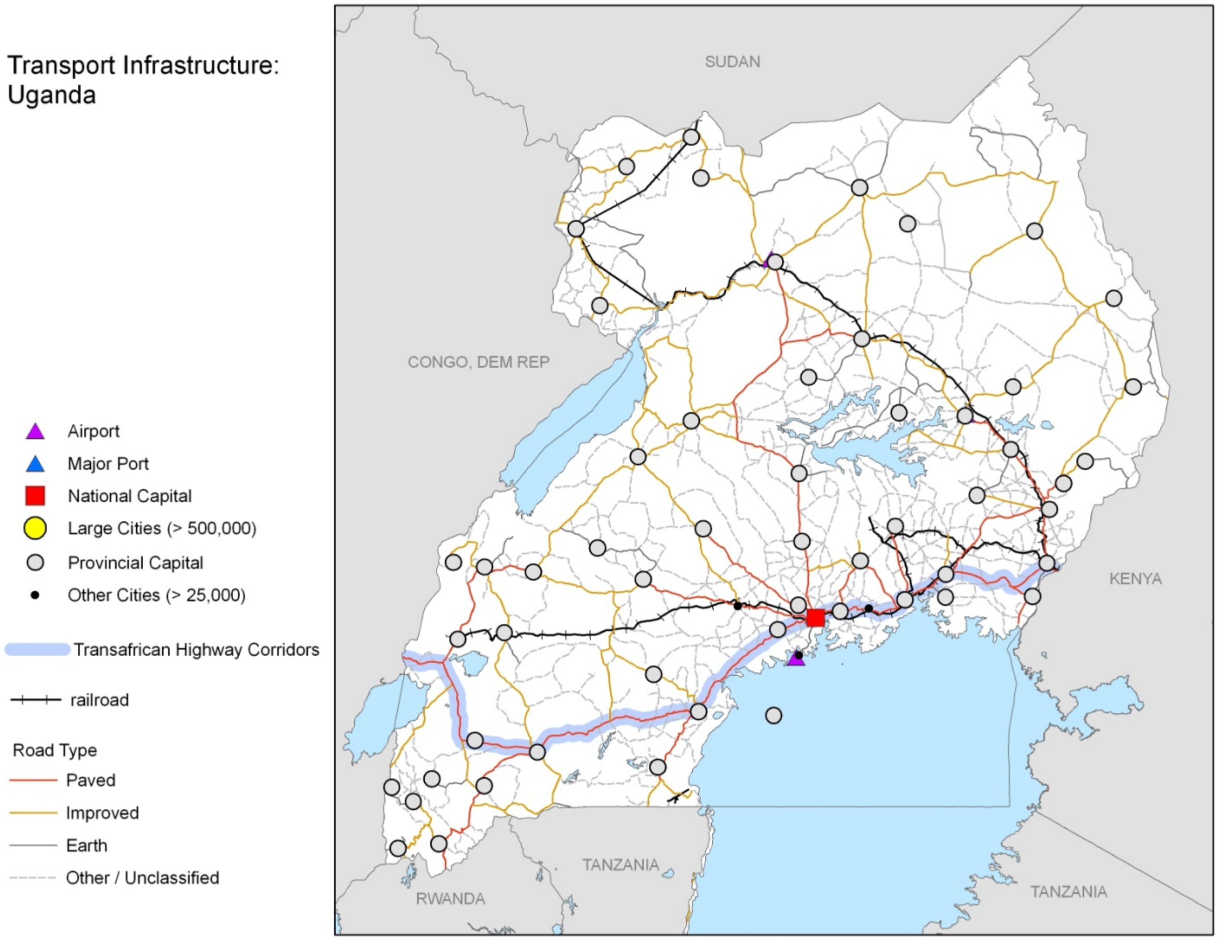
(c) Population by district

(c) Poverty count


Population by District
Year 2002


Poverty Count
Year 2002
1 Dot = 1,000

Annex 14: Uganda road network



Source: Carruthers (2008).